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TECHNICAL REPORT

A Methodology for Comparing Costs and Benefits of Management Alternatives for F-22 Sustainment

Cynthia R. Cook • Michael Boito • John C. Graser • Edward G. Keating
Michael J. Neumann • Ian P. Cook

Prepared for the United States Air Force

Approved for public release; distribution unlimited

RAND PROJECT AIR FORCE

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Preface

In 2007, the U.S. Air Force planned to contract with Lockheed Martin, which would act as the product support integrator (PSI) to manage weapon system sustainment for the F-22 air vehicle, and with Pratt & Whitney, which would fulfill the same role for the F119 engine. (The contracts would continue the existing sustainment approach featuring public-private partnerships, in which most depot repair work is managed by the contractors but is performed in Air Force depots.) Before it could award such contracts to the prime vendors, the Air Force was required by Public Law 105-261, section 346 (and as amended by Public Law 106-65, Section 336) to perform a cost-benefit analysis to demonstrate that the proposed approach would yield savings over an organic sustainment strategy.

The Air Force asked RAND Project AIR FORCE (PAF) to conduct the required cost-benefit study. In its analytic approach, the PAF study team defined notional organic sustainment organizations for purposes of comparison and compared the Air Force's current plans to use contractors to manage F-22 sustainment against plans for a gradual transition to notional organic alternatives. *This report presents the portions of those findings that are available to the public.* Where the numbers supporting the cost analysis or the results of the analysis are not available, the report presents the methodology used in the analysis without providing the results.

The research and analysis reported here was sponsored by the Air Force Program Executive Officer for the F-22 Program, Office of the Assistant Secretary of the Air Force for Acquisition, Headquarters U.S. Air Force, and conducted within the Resource Management Program of PAF for a fiscal year (FY) 2007 project, "F-22A Sustainment Cost/Benefit Analysis and Reparable Assessment Review." The project's technical monitor was Sue Dryden, Director of Sustainment and Logistics, F-22 Program Office, Aeronautical Systems Center, Wright-Patterson Air Force Base (AFB), Ohio.

This report should be of interest to those involved with the sustainment of the F-22 and other aircraft systems for the U.S. Department of Defense, as well as those in the field of cost estimation of weapon system sustainment activities.

Related PAF research that may be of interest to the reader includes the following:

- *Contractor Logistics Support in the U.S. Air Force*, Michael Boito, Cynthia R. Cook, and John C. Graser (MG-779-AF)
- *F-22A Multiyear Procurement Program: An Assessment of Cost Savings*, Obaid Younossi, Mark V. Arena, Kevin Brancato, John C. Graser, Benjamin W. Goldsmith, Mark A. Lorell, Fred Timson, and Jerry M. Sollinger (MG-664-OSD)

- *Lessons Learned from the F/A-22 and F/A-18 E/F Development Programs,* Obaid Younossi, David E. Stem, Mark A. Lorell, and Frances M. Lussier (MG-276-AF).

RAND Project AIR FORCE

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Background

The U.S. Air Force has changed its F-22 sustainment plans several times over the past two decades. The F-22 was originally intended to be an organically supported aircraft,[1] but its sustainment approach was changed to a contractor logistics support approach during the 1990s. Sustainment plans were subsequently changed to feature public-private partnerships using performance-based logistics (PBL). Under this approach, much of the hands-on depot repair work would take place at government depots, but Lockheed Martin would manage the supply chain and be responsible for overall sustainment of the air vehicle as the PSI. Pratt & Whitney would have similar responsibilities for the F119 engine. (See pp. 13–22.)

Public Law 105-261, Section 346 (and as amended by Public Law 106-65, Section 336) requires the military services to perform cost-benefit analyses before prime-vendor contracts for depot maintenance and repair can be awarded. After an internal Air Force analysis regarding the nature of the requirement, the F-22 System Program Office (SPO) (subsequently renamed the 478th Aeronautical Systems Wing, or ASW) asked PAF to conduct the congressionally mandated cost-benefit analysis to determine whether the proposed public-private partnership sustainment strategy would be less costly than an organic sustainment strategy. RAND conducted cost-benefit analyses comparing Lockheed Martin as the air vehicle PSI and Pratt & Whitney as the engine PSI to respective notional organic alternatives. These results were incorporated into a larger report produced by the SPO and delivered to Congress according to the requirements of the law. The Air Force also asked RAND to examine the process used for assigning the depot-level reparable (DLR) workload, a task that was not generated by the congressional requirement. This report describes the methodology used in that analysis, which was conducted from May to November 2007.[2] (See pp. 23–32.)

Methodology

Developing F-22 Sustainment Alternatives

Although the law implies that a cost comparison should be conducted, it does not specify what should be compared to the prime-vendor contract. As a result, the study team developed

1 *Organic* refers to work managed in-house by the government.

2 The analysis was originally supposed to be completed in July 2007 in support of an early fall contract award. However, the deadline was extended because of the additional time that the SPO needed for negotiations with the contractors and the concomitant lack of data available for this research.

notional government PSI alternatives for comparison to the Air Force's planned approach, evaluating two alternatives for both the air vehicle and the engine: the planned use of contractor-managed sustainment for the F-22 air vehicle with a notional government alternative and the planned use of contractor-managed sustainment of the F119 engine with a notional government alternative. In both cases, the analysis focused on the costs that would change under the different alternatives. (See pp. 23–32.)

We used existing sustainment organizations for fighter aircraft as analogies to develop the notional government PSI organizations. The existing F-22 air vehicle and engine program offices served as starting points for the management organizations. We used insights from interviews with personnel from multiple combat aircraft program offices (including the F-16, F-15, B-2, and F-117 SPOs) to learn about government management of sustainment. (See pp. 23–32.)

This approach included the following assumptions:

- The bulk of the F-22 air vehicle sustainment organization would move to Ogden Air Logistics Center (ALC) at Hill AFB, Utah. (See pp. 23–27.)
- Since its sustainment is conducted primarily at Ogden ALC, the F-16 sustainment organizations are the baseline for the F-22 air vehicle notional organic PSI, with adjustments for differences in the programs, including the absence of F-22 foreign military sales and increased F-22 technical complexity.[3] (See pp. 28–31.)
- The majority of the F119 engine sustainment organization would be located at Oklahoma City ALC at Tinker AFB, Oklahoma. (See pp. 27–28.)
- The F100[4] engine sustainment organization is the model to build the F119 notional organic PSI, with adjustments for differences in the programs. (See pp. 28–31.)
- Some characteristics of the planned sustainment approach would not change under either PSI approach. Most hands-on maintenance and repair work would still be done organically, and sustainment tasks traditionally performed by contractors, such as some of the sustaining engineering, would continue to be done by the contractors. (See pp. 31–32.)

Because the contractor management functions would not be eliminated entirely in the case of the organic PSI alternatives, it was necessary to assess the contractors' sustainment management structures and determine what workload would be retained, decreased, or eliminated with an organic PSI. This approach and the assumptions were vetted with the prime contractors. (See pp. 32–33.)

Timing

To present a realistic comparison, we compared the Air Force's 2007 plans to use Lockheed Martin and Pratt & Whitney as the air vehicle and engine program PSIs, respectively, against plans for a gradual transition from contractor PSIs to organic PSIs. We found that immediately

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[3] The F-16 sustainment organization at Hill AFB differed in structure from the F-15 sustainment organizations at Warner Robins AFB. The F-16 organization at Hill AFB was chosen as the most appropriate baseline because its structure allowed more straightforward assessments and adjustments of staffing and because it, like the F-22's sustainment organization, is based at Hill AFB.

[4] The F100 is a turbofan engine that powers both the F-15 and the F-16. It is produced by Pratt & Whitney.

standing up organic sustainment organizations for the F-22 was unrealistic and focused on a more feasible case.

We also note that the F-22 and F119 programs are relatively immature. For example, when this research was being conducted, the F-22 air vehicle had not completed the 100,000 flight hours that typically signify weapon system maturity.[5] (That milestone normally implies an increased level of certainty about a variety of aspects of system performance and maintainability, including many relating to costs.) This means that some predictions of future costs are currently relatively speculative; at the time of this research, the F-22 fleet had accumulated fewer than 40,000 total flight hours. (See pp. 32–33.)

Focus on Cost Differences

In addition to developing notional organic organizations to provide comparable functions while using different organizational structures, it also was challenging to develop comparable cost estimates for two organizations (contractor and organic) using very different cost accounting systems. (See pp. 35–40.)

To conduct this analysis, our approach focused on the cost *differences* between the two sustainment approaches, particularly those relating to sustainment management functions. Any activity that was estimated to remain constant under both approaches was not specifically analyzed, since it would not be a discriminator between the two approaches. Indeed, the majority of sustainment activities would remain unchanged regardless of the choice of PSI. This includes, for example, much of the engineering and technical support provided by the contractors as well as the hands-on maintenance and repair work that will take place on the flight line and at the ALCs. (See pp. 35–40.)

Summary of Selected Findings

We determined that schedule considerations preclude the rapid establishment of organic PSI organizations to manage F-22 air vehicle and F119 engine sustainment. Establishing an organic PSI would require multiple years to program and budget resources,[6] followed by a number of additional years to hire the necessary organic workforce and develop the human capital needed to manage F-22 and F119 sustainment.[7] As a result, it would be several years before the Air Force could reasonably expect to perform F-22 sustainment management organically. Under this notional alternative approach, the Air Force would continue with the planned contractor PSIs through most of the transition period, with no change in the initial years, building up organic capacity to manage all aspects of F-22 and F119 sustainment toward the middle of the transition phase before completing the transition to the organic approach. (See pp. 31–32.)

Based on this assumption for the transition to an organic PSI approach, costs would remain the same as in the contractor PSI case for the initial years of the transition phase. How-

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5 System maturity at 100,000 hours is a common rule of thumb for aircraft. For example, see Tirpak, 2007.

6 It is possible to reprogram funding from existing programs during an FY, despite the resulting disruption to the affected program, and Air Force leadership could have done so in early FY 2008 to begin establishing an organic PSI. However, the results of this study, delivered to the Air Force at that time, provided no compelling reason for an immediate change in sustainment plans, as explained in the text.

7 A detailed list of what specific functions would move to the Air Force is available in Appendix A.

ever, government manpower costs would increase in the middle of the transition phase as the organic organizations stand up. Conversely, contractor manpower would start to decline near the end of the transition period. Personnel costs in these middle years are estimated to be half-year costs, reflecting the assumption that personnel will be phased in over the course of each year. In the final year of the transition, the organic PSI organizations are assumed to be fully staffed as they take over supply chain management responsibility from the contractor PSIs. (See pp. 41–42.)

An earlier RAND publication included a cost analysis comparing the notional organic and contractor PSI approaches.[8] Our estimate separated the direct labor costs from the material and surcharge costs. For the contractor PSI cases, we used the direct labor costs that the contractors provided. For the organic PSI case, we assessed what portion of these direct labor costs would be eliminated if the PSI were moved. We decremented that portion from the original estimate and added in the amount of direct labor required in new government organizations. In both cases, the base material costs were provided by the contractors (we considered them to be the most reasonable estimates), and contractor and government surcharges were applied using the appropriate methodology for each case. (See pp. 41–42.)

It should also be noted that the direct labor charges cover different aspects of weapon system management under the two different approaches (contractor and organic), so they are not directly comparable. The surcharges also cover different aspects of costs, so the combined material and surcharge costs are also not directly comparable. (For example, more of the personnel costs of managing weapon system sustainment are direct charges under the contractor case, but in the organic cases, these are covered by surcharges on material costs.) The estimated total costs can be compared as bottom-line estimates. (See pp. 41–42.)

This report describes the portions of our findings that are available to the public. The estimated cost differences represent a small percentage of F-22 PSI annual recurring costs and are an even smaller percentage of overall F-22 sustainment costs, which include squadron maintenance personnel, for example. (See pp. 41–42.)

Benefits

We also assessed benefits claimed by representatives of the contractors and government sustainment organizations. Although it was not possible to validate and quantify the asserted benefits, if either the organic or contractor PSIs could prove to offer superior service, particularly in the form of any metric related to aircraft availability (such as better not-mission-capable-due-to-supply rates), the value of greater availability could overshadow the cost differences identified in our analysis. (See pp. 43–44.)

Potential PSI management benefits asserted by the contractor come from such initiatives as centralized asset management of spare parts, a combined supplier base (with other programs), better information systems and databases, integration of supply chain management with engineering, funding flexibility, and the ability of profits to motivate performance. Although we judge that some of these are, in fact, real benefits to the contractor (which can more quickly and flexibly invest in computer upgrades, for example), others did not offer an inherent advantage to either side because both could realize them (and, in some instances, were

[8] The document is not available to the general public.

trying to do so). In any case, we were not able to monetize the benefits these would provide. (See pp. 44–54.)

Other Issues

Our analysis also uncovered a number of issues of interest to analysts. One of these involved so-called technical data rights. At the outset of this analysis, the cost of technical data rights was purported to be an important discriminator between the approaches. Further research revealed that the term *technical data rights* has several meanings; the most relevant definition for this study refers to repair instructions. Because the vast majority of the repair work is taking place at government depots, the government must pay for repair instructions no matter which alternative is selected.[9] There is no strong evidence indicating that a contractor PSI would reduce these costs. (See pp. 55–60.)

The analysis of the F-22 process for assigning DLR workload revealed that most workload assignments were already largely determined by core and 50/50 requirements.[10] Most of the effort in the depot partnering assessment was thus going into documenting already-decided outcomes (in which core limitations meant that work was required to be performed organically) or producing outputs that were informative but did not appear to affect outcomes. (See pp. 55–60.)

Recommendations

An important implication of the cost differences identified in our analysis is that the issue is worthy of further study involving a more detailed comparison.[11] *Hence, a full-scale business-case analysis that could more accurately assess costs of the two approaches should be started relatively soon.*[12] Such an analysis would improve the Air Force's ability to show that either contractor or organic management of F-22 air vehicle and F119 engine sustainment represents the best value for the Air Force and for the taxpayer. Given the time necessary to develop an organic capability, a later start to the business-case analysis will mean a later transition to organic support, should that be the option chosen. However, this must be balanced against the fact that starting

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9 The payment is for the costs that the contractors incur in preparing the repair instructions in such a way that government workers can use them.

10 These are congressionally mandated limits on the sustainment work that can be done by contractors. The "core" requirement maintains the organic government skills necessary to perform the various classes of repair work deemed critical to the mission. Not all of this work has to be done in-house, but enough has to be done to maintain the capability. The 50/50 limit on contractor sustainment is another broad effort to maintain the capability in-house. The laws and their histories are explained in Cook, Ausink, and Roll, 2005.

11 This could include a more specific count of individuals undertaking specific tasks instead of broad estimates based on analogies to other organic sustainment programs.

12 The description of what is contained in a formal business case analysis can be found on Defense Acquisition University's website (see DAU, undated[a]). It is an extensive analysis, beyond the scope of this more limited study, which was specifically aimed at helping the Air Force meet certain legislative requirements in a time-constrained condition.

the business-case analysis later would mean that the program would be more mature and that more insight into future costs would be available.[13] (See p. 61.)

Current plans to motivate contractor performance using a systemwide PBL contract will be challenging under an organic approach.[14] No approaches have been identified to provide incentives to government workers or organizations as effectively as monetary awards can be used to motivate contractors. Government organizations cannot be paid an increased fee to perform more effectively. Individuals can get bonuses or "comp" time,[15] but these are small incentives compared to those available in the private sector. *For PBL to work with an organic approach, efforts should be made to create new incentives for improved government performance.* (See p. 62.)

Along with providing incentives for better performance, the government could benefit by pursuing efforts to measure performance attributable to the logistics provider. An in-depth business-case analysis of the alternative F-22 sustainment providers should include logistics performance and, ideally, allow the comparative performance assessment of alternative logistics providers. The ability to assess logistics performance requires reliable data, as well as the expertise and methodologies necessary to assess the data. *We suggest that the Air Force invest in developing the data and analytic capabilities needed for better comparisons among logistics providers, not just for the F-22 and F119 programs but for all Air Force weapon systems.* (See p. 62.)

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[13] Shortly after this recommendation was made to the F-22 SPO, it began looking into it and subsequently awarded a contract for a business-case analysis to another organization.

[14] The PBL approach suggests that cost control will lead to greater profit margins for the contractors in the near term. The goal is that savings (in the form of either negotiated lower contract costs or avoidance of contract cost growth) will accrue to the government when follow-on contracts are negotiated, although this is unpredictable. In addition, contracts theoretically can be structured so that profits or savings are shared in some proportion between the government and the contractor, allowing the government to realize savings immediately. However, managing effectively in this manner can be challenging, particularly if the government does not have insight into contractor costs and profit margins.

[15] This was true at the time the research was conducted. One of our reviewers indicated that there are no longer any funds available for these bonuses.

Acknowledgments

The authors are grateful to many individuals in the Air Force, at the contractors, and elsewhere who assisted in different aspects of this research effort. There are too many to name individually, but we thank them for their time and insights and take this opportunity to mention some people who were extraordinarily helpful. All ranks and organizations listed here were current at the time of this research.

Walter Upham and Sterling Johnson at the 478 ASW provided a great deal of background information on F-22 sustainment decisions, related studies, and other documentation. Walt also served as our main point of contact during the study and was outstandingly helpful throughout.

Sue Dryden and Brigadier General C. D. Moore of the 478 ASW provided contacts and opened doors throughout the Air Force so that we could collect relevant information from other organizations and otherwise supported our efforts to conduct a balanced analysis. Their insights also strengthened the study in many ways.

Jim Schalbrack at 508 ASW, Hill AFB, coordinated and hosted our visit to learn more about organic sustainment of the F-16 and cheerfully provided us with information on a host of related issues.

Charles Sargeant, 577th Aeronautical Systems Group, Wright-Patterson AFB, provided helpful insights on engine sustainment issues.

Nicole Fleischer at the Oklahoma City ALC, Tinker AFB, coordinated our visit to learn about organic and contractor sustainment of fighter engines and addressed follow-up questions.

Many others in the Air Force, particularly at the ALCs and at Headquarters Air Force Materiel Command, offered both data and insights based on years of experience with issues touched on in this analysis.

At Lockheed Martin, Brian Jackson had responsibility for collecting and providing data to the research team, which he did with efficiency, grace, and a great deal of patience. He also provided useful insights on a variety of the topics covered in this report. Brian's colleagues Dennis Haines and Scott Ogden also provided information and discussion. We would also like to take this opportunity to remember their Lockheed Martin colleague, Larry McQuien, who passed away while this report was being readied for publication. Larry had supported multiple RAND cost and acquisition studies in past years, and we will miss his clarity of thought, kindness, and good humor.

At Pratt & Whitney, our main point of contact was Randy LaMar, who was unfailingly prompt and helpful in responding to our requests.

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Abbreviations

AFB	Air Force base
AFI	Air Force Instruction
AFMC	Air Force Materiel Command
AFSO21	Air Force Smart Operations for the 21st Century
AFTOC	Air Force Total Ownership Cost
ALC	air logistics center
ASG	aircraft sustainment group
ASM	Aircraft Sustainability Model
ASW	aeronautical systems wing
BOCR	business operations cost recovery
CBSS	combat sustainment squadron
CLS	contractor logistics support
CY	calendar year
D035K	Wholesale and Retail Receiving and Shipping System
DFARS	Defense Federal Acquisition Regulation Supplement
DLA	Defense Logistics Agency
DLR	depot-level reparable
DMI	depot maintenance interservicing
DoD	U.S. Department of Defense
DPA	depot partnering assessment
Dyna-METRIC	Dynamic Multi-Echelon Technique for Recoverable Item Control
FAR	Federal Acquisition Regulation
FASTeR	Follow-on Agile Support for the Raptor

FMC	fully mission capable
FS&T	Field Support and Training
FY	fiscal year
IMIS	Integrated Management Information System
LogPAS	Logistics Performance Assessment System
MC	mission capable
MCR	material cost recovery
MERLIN	Multi-Echelon Resource Logistics Information Network
NADEP	naval air depot
OEM	original equipment manufacturer
PAF	RAND Project AIR FORCE
PALS	performance-based agile logistics support
PBL	performance-based logistics
PSI	product support integrator
SBSS	Standard Base Supply System
SMAG	Supply Management Activity Group
SOR	source of repair
SORAP	Source of Repair Assignment Process
SPO	system program office
U.S.C.	United States Code

CHAPTER ONE

Introduction and Study Methodology

Introduction

The Air Force has changed its F-22 sustainment plans several times over the past two decades. The F-22 was originally intended to be an organically supported aircraft, but its sustainment approach became one involving contractor logistics support (CLS)[1] during the 1990s and was subsequently changed to the current approach, which involves public-private partnerships[2] using performance-based logistics (PBL).[3] Much of the hands-on sustainment work (including maintenance and overhaul) will be done by government workers at Air Force depots, but the Air Force plans to hire Lockheed Martin to manage sustainment of the air vehicle as the product support integrator (PSI)[4] and Pratt & Whitney to manage sustainment of the F119 engine.

There are particular legal requirements that the Air Force and the other military services must fulfill before issuing such a contract. Beginning in 1998, these laws[5] required DoD to

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1 CLS is "contractor sustainment of a weapon system that is intended to cover the total life cycle of the weapon system and generally includes multiple sustainment elements" (Boito, Cook, and Graser, 2009, p. xiii).

2 In a public-private partnership, commercial companies (contractors) can manage work performed by government employees at government-owned facilities or occupy unused portions of the facilities, as allowed in 10 U.S.C. 2474, Centers of Industrial and Technical Excellence: Designation; Public-Private Partnerships.

3 PBL arrangements occur when logistics organizations are held accountable for attainment of performance metrics specified in advance. One definition describes it as "a variation of other contractor logistics support strategies [that] involves defining a level of performance that the weapon system is to achieve over a period of time at a fixed cost to the government" (U.S. Government Accountability Office, 2005, p. 1). The focus is on output metrics, such as weapon system availability, rather than on inputs, such as worker hours spent maintaining the system (see DAU, 2005). The PBL approach suggests that careful cost control will lead to greater profit margins for contractors in the near term because they have agreed to provide a service for a predetermined price, so reducing their own costs increases their profits. It is theoretically possible that contracts can be structured to share profits or savings in some proportion between the government and the contractor so that the government realizes savings immediately. Another longer-term goal is that savings (in the form of either negotiated lower contract costs or avoidance of contract cost growth) will accrue to the government when follow-on contracts are negotiated. The use of PBL has been mandated by the U.S. Department of Defense (DoD) in acquisition regulations, including DoD Directive 5000.1 (2003).

4 According to the Defense Acquisition University (undated[b]), the PSI is "an entity performing as a formally bound agent (e.g. contract, Memorandum of Agreement, Memorandum of Understanding) charged with integrating all sources of support, public and private, defined within the scope of the Performance Based Logistics (PBL) agreements to achieve the documented outcomes."

5 Public Law 105-261, Section 346, 1998:

> Sec. 346. Conditions on Expansion of Functions Performed Under Prime Vendor Contracts for Depot-Level Maintenance and Repair.
>
> (a) Conditions on Expanded Use. The Secretary of Defense or the Secretary of a military department, as the case may be, may not enter into a prime vendor contract for depot-level maintenance and repair of a weapon system or other military

perform an analysis of costs and benefits demonstrating savings to the government before issuing a so-called prime-vendor contract to manage sustainment. The F-22 System Program Office (SPO) asked RAND Project AIR FORCE (PAF) to conduct a study as required by the law, to be completed in advance of its plans to issue sustainment contracts in the fall of 2007. The resulting cost-benefit analyses compared Lockheed Martin as the air vehicle PSI and Pratt & Whitney as the engine PSI to respective notional organic alternatives. The results were incorporated into a report produced by the SPO that it then delivered to Congress according to the requirements of the law.[6] The Air Force also asked RAND to examine the process used for assigning the depot-level reparable (DLR) workload, a task that was not generated by the congressional requirement. This report outlines the results and the methodology used in the analyses.

History of F-22 Sustainment Issues

The F-22 aircraft derives from the Advanced Tactical Fighter program that began in the early 1980s and was awarded to an industrial team composed of Lockheed Martin, General Dynam-

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> equipment described in section 2464(a)(3) of title 10, United States Code, before the end of the 30-day period beginning on the date on which the Secretary submits to Congress a report, specific to the proposed contract, that—
>
> (1) describes the competitive procedures to be used to award the prime vendor contract; and
>
> (2) contains an analysis of costs and benefits that demonstrates that use of the prime vendor contract will result in savings to the Government over the life of the contract.
>
> (b) Definitions—In this section:
>
> (1) The term "prime vendor contract" means an innovative contract that gives a defense contractor the responsibility to manage, store, and distribute inventory, manage and provide services, or manage and perform research, on behalf of the Department of Defense on a frequent, regular basis, for users within the Department on request. The term includes contracts commonly referred to as prime vendor support contracts, flexible sustainment contracts, and direct vendor delivery contracts.
>
> (2) The term "depot-level maintenance and repair" has the meaning given such term in section 2460 of title 10, United States Code.
>
> (c) Relationship To Other Laws—Nothing in this section shall be construed to exempt a prime vendor contract from the requirements of section 2461 of title 10, United States Code, or any other provision of chapter 146 of such title.

Amended in Public Law 106-65, Section 336, 1999:

> 336. Additional Matters To Be Reported Before Prime Vendor Contract for Depot-Level Maintenance and Repair Is Entered Into.
>
> Section 346(a) of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (Public Law 105-261; 112 Stat. 1979; 10 U.S.C. 2464 note) is amended—
>
> (1) by striking "and" at the end of paragraph (1);
>
> (2) by striking the period at the end of paragraph (2) and inserting a semicolon; and
>
> (3) by adding at the end the following new paragraphs:
>
> "(3) contains an analysis of the extent to which the contract conforms to the requirements of section 2466 of title 10, United States Code; and
>
> "(4) describes the measures taken to ensure that the contract does not violate the core logistics policies, requirements, and restrictions set forth in section 2464 of that title."

[6] The report included other information required by the law that was not part of the scope of this study. The PAF study team was not provided with a copy of this limited-distribution report, and we do not have details to provide a complete reference for it.

ics, and Boeing staff. General Dynamics' participating division was subsequently purchased by Lockheed Martin, which has a leading role in design, production, and sustainment. According to the Air Force, the technological advances provided by the F-22 are in the areas of stealth, supercruise, maneuverability, and integrated avionics.[7]

The program has undergone many changes of direction during the aircraft's development and fielding. The Milestone II decision in 1991,[8] which allowed the program to enter the production phase, approved a total program buy of 750 aircraft and directed the U.S. Air Force supply chain and air logistics centers (ALCs) to provide organic sustainment (which was the usual approach for fighters at the time) beginning with the first production F-22 aircraft (F-22 SPO, 2007a, attachment 1, p. 5). During the 1990s, the approved number of production F-22s was reduced several times, with the current approved program being 187[9] of the twin-engined aircraft and about 450 F119 engines, including spares. The F-22 reached initial operating capability in December 2005.

Along with these reductions in aircraft procurement numbers, the F-22 support concept also underwent a series of changes that can be understood as part of the larger DoD climate of acquisition reform in the 1990s, which looked to the private sector as a source of best practices. In 1994, the F-22 Program Executive Officer asked the SPO to determine whether costs could be reduced by privatizing the program support. The resulting logistics privatization study was completed in April 1995 and included analysis of two options based on a program of 442 aircraft (*F/A-22 Logistics Privatization Study*, 1995). One option would use a single prime contractor to provide logistics support over the life of the program, while the other would use a competitive approach, with several contractors competing to provide F-22 logistics support. The study forecast a significant savings if the first option were implemented. In December 1996, a joint estimating team chartered by the Assistant Secretary of the Air Force for Acquisition recommended, and the Chief of Staff of the Air Force approved, a CLS strategy for the F-22 (*F-22 Joint Estimate Team Final Report*, 1997). Thus, the Air Force's initial organic support strategy was completely changed, and subordinate decisions concerning depot capabilities, technical data, and logistics support analyses were aligned with the CLS approach.

In the late 1990s and early in the following decade, three factors external to the F-22 influenced its sustainment strategy. The first was the modification of 10 U.S.C. 2474, Centers of Industrial and Technical Excellence: Designation; Public-Private Partnerships, which allowed public depots to enter into public-private cooperative arrangements in order to conduct depot-level maintenance and repair activities and to sell their repair services to private contractors. As part of that approach, contractors have unprecedented control over aspects of sustainment, including, for example, repair induction and delivery schedules.

The second factor was the adoption of the PBL concept in the 2001 Quadrennial Defense Review as the preferred DoD strategy for providing weapon system logistics support for both new and existing legacy systems. The third factor was the Air Force's difficulty achieving the requirements of 10 U.S.C. 2466, which specify that at least 50 percent of the service's depot maintenance and repair workload by dollar amount be performed at a government depot.

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7 Air Force fact sheets offer extensive details on weapon systems. See, for example U.S. Air Force, 2009, which also references Pratt & Whitney's F119-PW-100 turbofan engine, produced for the F-22.

8 Milestone II has been modified and renamed Milestone B under the DoD 5000-series regulations.

9 One was lost in a crash in March 2009, leaving a planned force of 186 as of this writing.

Work performed by government employees in government depots under the depot partnering agreements[10] counted for meeting the "50/50" limitation, so there was a strong push to place work in the ALCs via partnerships to replace workload lost as older systems retired. In addition, 10 U.S.C. 2464 (Core Logistics Capabilities) requires that sufficient workload be assigned to the depots "to ensure cost efficiency and technical competence in peacetime while preserving the surge capacity and reconstitution capabilities necessary to support fully strategic and contingency plans." Stated another way, the "core" requirement calls for the maintenance of sufficient government skills to perform the various classes of repair deemed critical to missions that the military services may be asked to perform. The confluence of these factors led to the partial reversal of the 1996 F-22 CLS decision, particularly since much of the F-22 workload was designated "core" in accordance with 10 U.S.C. 2464.

Current F-22 Sustainment Strategy

As a result of these factors, in December 2002, Headquarters Air Force changed the F-22 sustainment strategy to contractor support implemented through public-private partnerships. Core workload would be performed in government depots. Specifically, the guidance included the following requirements:[11]

- Life-cycle support would be managed through a long-term, performance-based contract.
- The relationship between Lockheed Martin, Boeing, Pratt & Whitney, and the Air Force would remain throughout the life of the weapon system, although specific roles could change over time.
- Depot maintenance workload designated core would be reserved for organic resources, and other depot maintenance workloads would be allocated based on best value (F-22 SPO, 2007a).

In November 2003, the F-22 Partnering Charter for the air vehicle was signed, and in May 2005, a partnering agreement was approved by the F-22 SPO, the three prime contractors, and the ALCs. Under this agreement, most organization- and depot-level maintenance will continue to be performed by government personnel at government-owned depots. Some depot maintenance of the air vehicle is taking place at Lockheed Martin's Palmdale facility. (A detailed list of sustainment functions can be found in Appendix C.)

In June 2006, the Air Force's Acquisition Strategy Panel, chaired by the Assistant Secretary of the Air Force for Acquisition, approved the support strategy proposed by the F-22 SPO, which includes

- a ten-year business arrangement with PBL contracts beginning in calendar year (CY) 2008
- separate sole-source contracts with Lockheed Martin for the air vehicle support and with Pratt & Whitney for F119 engine logistics support
- partnerships with the depots.

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[10] The depot partnering agreements are established between the depots (or ALCs) and private contractors as allowed under 10 U.S.C. 2474.

[11] The guidance was contained in a joint memo by the Secretary of the Air Force for Acquisition and the Air Force Deputy Chief of Staff for Installations and Logistics (Headquarters U.S. Air Force, 2002).

The strategy included award fees based on performance metrics, such as aircraft availability (F-22 SPO, 2007a, p. 19). We note that during the development of this longer-term sustainment strategy, the Air Force contracted with the prime contractors for sustainment, using a cost-plus-award-fee contract structure.

The SPO implemented this direction and prepared to award contracts with these characteristics to the Lockheed Martin/Boeing team for air vehicle sustainment and to Pratt & Whitney for F119 engine sustainment. As part of that implementation, the SPO issued a request for information in 2004 to request inputs from contractors on the best use of a PSI to achieve the most effective F-22 sustainment under a PBL approach.

Because the Air Force determined that the Lockheed Martin/Boeing team and Pratt & Whitney were the only reasonable alternatives to serve as prime contractors for F-22 sustainment, sole-source contract awards were approved for both contracts, with the period of performance originally planned to begin for both on January 1, 2008. These contracts were to be similar in that the SPO planned to contract with (and provide payment to) the primes for sustainment services under a PBL strategy, with performance metrics determining part of the contractors' fee (profit). The primes are to establish partnering agreements with the three Air Force ALCs where the majority of the depot repairs are to be conducted. The primes are to pay the ALCs directly for their efforts and will, in turn, collect payments from the F-22 SPO for these repairs, as well as supplies, supply chain management, and a host of other activities.

Cost-Benefit Analysis Required

Before the Air Force could award either of the sole-source contracts, it was required by Public Law 105-261, Section 346, later amended by Public Law 106-65, Section 336, to demonstrate through analysis that the proposed public-private partnership sustainment strategy would be less costly than an organic sustainment strategy. In the spring of 2007, the Air Force asked PAF to conduct the required cost-benefit analysis, with the expectation that the analysis would be completed in the summer to support decisionmaking about F-22 sustainment in the fall.

Overview of Study Methodology

The first task undertaken by the study team was developing the appropriate scope to help the SPO meet the congressional requirements and to ensure that it had the best baseline information for future decisions. The first question was the length of time to consider for the comparison between the alternatives. Because of the proposed structure of the contract (a five-year period of performance from CYs 2008 through 2012 at the time of the initial analysis), the study team (in concert with the SPO) determined that five years would offer a reasonable length of time to consider.[12]

In the absence of an officially planned government alternative, the study team also had to decide on and develop notional organic sustainment approaches for both the air vehicle and

[12] One reviewer pointed out that this overlaps with the remaining term of F-22 production. Theoretically, there may be efficiency benefits for the contractor alternative from the overlap of production and sustainment. These benefits would be difficult to measure and may not even hold in this case. Much of the sustainment work will be taking place at government depots under either alternative, so costs are unlikely to differ between the two approaches. In any case, the overlap is coincidental to our analysis. At the time of this research, there was some expectation that F-22 production would continue past the 187-aircraft final production quantity.

the engine. As described later, we used existing organic programs as starting points in developing these notional approaches.

The research team investigated what activities should be included as relevant to the *management* of sustainment. The contractors provided integrated proposals that did not separate management tasks from other kinds of work, so the team had to parse out the management-oriented tasks that were relevant to the PSI role. The PSI is responsible for integration or management of tasks and does not perform the actual weapon system sustainment tasks, which can be completed by organic or contractor organizations. We researched sustainment approaches and worked with the contractors and the government to determine which activities would most likely stay with the contractors under an organic approach and which would transition to government control.

The analysis for the cost comparisons had to account for numerous specific challenges. One issue was that the government and the prime contractors have different methods for estimating the costs of the same activities. The vast majority of prime-contractor labor costs (except vendor managers) are direct charges, meaning that an individual working on a specific program charges to that program. By contrast, while some government labor is direct-charged to programs, a large percentage of these costs are estimated and assigned in the form of surcharges on other expenses, such as the cost of materials purchased. (Surcharges are commonly used for charging the labor of consolidated functions.) There are differences in how the government and prime contractors track certain material costs as well, with contractors more likely to use direct charges while the government uses surcharges.

Along with determining the amount of work that the organic alternative would do and how it would be accounted for in terms of direct charges or surcharges, we also had to develop an estimate for the costs of labor and likely growth over the five years. We used information from other government organizations on the likely mix of military, government civilian, and contractor workers and from Air Force Instructions (AFIs) and the government on their costs. Labor costs were inflated at DoD Comptroller–developed rates. Contractor rates were taken from forward pricing rate agreements.

The cost portion of this analysis included an investigation into the cost of data rights, which had been raised as a potential significant cost of changing to an organic approach. We also reviewed available estimates and interviewed government and contractor experts to find out what was included in the data rights required for doing the work under consideration. We then estimated the likely costs if the government decided to take the management of the work in-house.

Assessing the benefits of the different approaches proved difficult for several reasons. The contractors provided considerable information on the benefits that they offered, but much of it was unquantifiable or not provable. Since the program is relatively new, there is little information available that is specific to performance. Furthermore, much of what contractors contend is unique to how they manage performance is also available to the government through the adoption of best practices. (There are, in fact, efforts under way to improve government performance in a variety of areas.) We interviewed government personnel at the SPO and at the likely depots to understand these efforts and to develop a picture of government-specific benefits. Finally, we interviewed personnel at other government program offices, spoke to experts in the field, and reviewed literature on sustainment performance.

The assessment of the assignment process for DLRs relied on reviewing government regulations on the required steps of the process, and the available documentation on how the F-22

SPO fulfilled these steps. Interviews with government personnel provided context and further information.

Developing the Two Sustainment Alternatives

The law required that the study contain "an analysis of costs and benefits that demonstrates that use of the prime vendor contract will result in savings to the Government over the life of the contract." Although the law's wording implies that a comparison should be conducted, it does not specify what should be compared to the prime-vendor contract. Because this type of legislation usually seeks to address concerns about maintaining the skill base and workload at organic depots, our analysis compares the planned use of contractor-managed sustainment with notional government alternatives.

We investigated two alternative management organizations for each workload. For the air vehicle, Lockheed Martin's proposal was compared with a notional organic alternative based on existing fighter programs for which the government takes lead responsibility in managing weapon system sustainment. Similarly, for the F119 engine, Pratt & Whitney's proposal was compared with a notional organic alternative based on organically managed engines.

Developing the notional contractor and organically managed sustainment alternatives proved to be analytically challenging. To develop the contractors' alternatives, the management structures had to be disentangled from the other activities contained in the contractors' proposals. Much contractor effort, such as sustaining engineering, would be retained under either alternative.

For the organic alternatives, we developed notional government organizations where none currently exists. The existing F-22 and engine program offices served as starting points for the management organizations. We used insights from interviews with personnel from multiple combat aircraft program offices (including the F-16, F-15, B-2, and F-117 SPOs) to identify elements typically included in government management of sustainment organizations.

The assumptions for this approach included the following:

- The bulk of the F-22 air vehicle sustainment organization would be located at Ogden ALC at Hill Air Force Base (AFB).
- Since its sustainment is conducted primarily at Ogden ALC, the F-16 sustainment organizations were selected to serve as the model for the F-22 air vehicle notional organic PSI, with adjustments for differences in the program, including the absence of F-22 foreign military sales and increased F-22 technical complexity.[13]
- The majority of the F119 engine sustainment organization would be located at Oklahoma City ALC.
- The F100 engine sustainment organization served as the model for the F119 notional organic PSI, with adjustments for differences in the programs.[14]

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13 The F-16 sustainment organization at Hill AFB differed in its structure from the F-15 sustainment organizations at Warner Robins AFB. The F-16 organization at Hill AFB was chosen as the most appropriate baseline because its structure allowed for more straightforward assessments and adjustments of staffing and because it, like the F-22, is based at Hill AFB.

14 The F100 is a turbofan engine that powers both the F-15 and F-16. It is produced by Pratt & Whitney.

- Characteristics of the planned sustainment approach other than the PSI were unchanged; that is, most hands-on maintenance and repair work would still be done organically, and sustainment tasks traditionally performed by contractors, such as some of the sustaining engineering, would continue to be done by the contractors.

Because the contractor management functions would not be eliminated entirely in the case of the organic PSI alternatives, it was necessary to assess the contractors' management structures and determine what workload would be retained, decreased, or eliminated with an organic PSI. This approach and assumptions were vetted with the prime contractors.

Focus on Cost Differences

In addition to developing the notional organic organizations to provide comparable functions while using different organizational structures, it also was challenging to develop comparable cost estimates for two organizations (contractor and organic) using very different cost accounting systems. With one notable exception,[15] this analysis applies the accounting methodology used by each PSI organization to that analytical alternative. As a result, although the costs in a particular category (for example, personnel) may not be directly comparable, the bottom-line PSI cost comparison is valid.

Rather than develop two complete cost estimates of the different PSI approaches, this analysis focused on the cost *differences* between the two sustainment approaches, particularly those relating to sustainment management functions. Any activity that was estimated to remain constant under both approaches was not considered or estimated separately, since it would not bear on the decision of which of the two alternatives was more cost-effective. Indeed, the majority of sustainment activities would not change if the PSI were organically managed—including, for example, much of the engineering and technical support provided by the contractors, along with the hands-on repair work conducted at the ALCs.

After identifying the activities that would remain the same and those that would change under the two alternatives, the next step was to determine how much the changes would cost and what the relative benefits would be. For a variety of reasons, the government and contractors account for costs differently. A major distinguishing factor is whether activities are "direct-charged"—that is, specifically identified and paid for with program funds (or paid for directly by appropriated funds, in the case of some of the government organizations)—or "indirect-charged," in which some costs are recovered using a surcharge on another cost. Table 1.1 identifies major cost accounting differences in how contractor and organic sustainment organizations pay for management activities.

The major difference is that far more contractor activities are billed as direct charges, including all materials and all PSI personnel except vendor managers, which are covered by a wrap rate or surcharge assessed on material.[16] Certain other material-related costs are charged indirectly, including transportation and storage. A fee or profit figure, then, is assessed on top

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[15] For replenishment spares, contractor estimates were determined to be a reasonable prediction of the direct costs to the Air Force, so these estimates were used for both the Air Force and the contractor cases.

[16] Material wrap rates are surcharges applied to the costs of material to cover labor involved in aspects of its purchase and/or management.

Table 1.1
Different Approaches Feature Different Cost Accounting

PSI Approach	Direct Charge	Indirect Charge
Organic	Aircraft sustainment group Repairs and consumables Modifications and heavy maintenance	Supply chain managers paid for by surcharges on repairs and consumables Replenishment spares funded by surcharge
Contractor	All PSI personnel except vendor managers Repairs, consumables, and replenishment spares Modifications and heavy maintenance	Material handling rate or material wrap rate includes vendor managers Fee or profit

of all costs, including costs for *all* work done at the organic depots under the public-private partnership arrangements.

Under the organic approach, direct charges pay for personnel who manage the aircraft system as a whole, including depot-level sustainment activities, as well as most material. However, supply chain management personnel are charged to the program as a surcharge on repairs and consumables, and replenishment spares are billed as a surcharge assessed on repairs. These organic surcharges are explained more fully in Chapter Four.

Schedule and Timing of Alternatives

We determined that it was unrealistic to conduct a comparison between the notional government and contractor PSI organizations with the assumption that changes would begin immediately. Planning for contractor-managed F-22 air vehicle and F119 engine sustainment has been under way for years, and it would be difficult to quickly develop parallel organic sustainment management organizations that would be functional within a few months. In more likely scenarios, the process of standing up new organic PSIs would take several years.

To present a realistic assessment, this report compares the Air Force's current plans to use Lockheed Martin and Pratt & Whitney as the air vehicle and engine program PSIs, respectively, against plans for a gradual transition from contractor PSIs to organic PSIs. It does not consider a case in which organic PSIs take over the work immediately, because that is a much less likely scenario. In fact, because of schedule constraints caused by the lead time in the government programming and budgeting system and the necessity of hiring and training employees to manage sustainment, we see no reasonable alternative to existing Air Force plans to use contractors as the sustainment PSIs for the next few years. It would take several years to plan for and develop the necessary in-house capabilities, as we discuss later in this report.

We also note that the F-22 and F119 programs were relatively immature when this research was conducted—that is, they had not completed the 100,000 flight hours that typically signify weapon system maturity;[17] thus, there is an increased level of uncertainty about aspects of system performance, including many relating to costs. This means that some predictions of future costs are relatively speculative.

[17] System maturity at 100,000 hours is a common rule of thumb in aviation. See, for example, Tirpak, 2007.

Summary of Findings

As described earlier, schedule considerations preclude the rapid establishment of organic PSI organizations to manage F-22 air vehicle and F119 engine sustainment. To establish an organic PSI, it would take multiple years to program and budget resources and additional years to hire and sufficiently train the requisite organic workforce, so it would be several years before the Air Force could reasonably expect to perform all activities required for F-22 sustainment management.

Based on that assumption for the transition to an organic PSI approach, costs would remain the same as the contractor PSI case for the initial years of the transition. However, manpower costs would be expected to increase in the middle years of the transition as the organic organizations stand up. (There will be some overlap in effort during this period.) Conversely, contractor manpower would start to decline toward the end of the transition. Our methodology incorporated this by estimating changes in personnel costs in these years as half-year costs, reflecting the assumption that personnel will be phased in over the course of each year. In the final transition year, the organic PSI organizations are assumed to be fully staffed as they take over supply chain management responsibility from the contractor PSIs.

The specific results of the cost analysis and the inputs to the analysis are not available to the general public and cannot be included in this report. We also note that these results are dependent on assumptions, as we discussed next. By the final transition year, the program will be more mature, and F-22 production will be complete (given current plans), so that year represents a reasonable baseline year for future PSI cost comparisons.

Caveats to Cost Estimates

The cost differences between organic and contractor PSIs identified in this analysis relied heavily on estimating assumptions. For instance, most government costs are in the form of surcharges, and government surcharge rates vary from year to year. Surcharges in 2012 and beyond could deviate from the range of rates used in this analysis.[18]

In addition, surcharge rates were applied to unconstrained estimates of material costs that are based on an immature F-22 program. (We accepted the contractors' material cost estimates for 2012 as the best information available for both contractor and organic approaches.) Future budget constraints and accumulated knowledge about the program could significantly alter these projected material costs.[19]

Another assumption concerns the burdening of labor rates. Contractor labor rates are fully burdened with overhead and other costs. The burdened government labor rates used in the analysis do not capture all of the overhead costs associated with operating all three sustainment organizations required for the F-22. The contractor labor rate includes the contractors' expenses for property, buildings, other infrastructure, and interest expenses, but the government already owns equivalent resources that are fully paid for. Organic labor rates are typically

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[18] The analysis used rates in the range from fiscal year (FY) 2004 to those shown in the Air Force's FY 2008 Working Capital Fund budget through FY 2009. The Defense Logistics Agency (DLA) is scheduled to take responsibility for purchasing new spares and to establish a new surcharge rate to cover these costs.

[19] Surcharge rates recover costs for personnel and services, especially transportation and warehousing services. The personnel costs are probably largely insensitive to changes in material costs. It is difficult to know how the cost of services might be affected by changes in material costs and whether a contractor or organic PSI might be affected differently, but we acknowledge that this is a possibility.

not burdened with the overhead costs of government property, buildings, and other support infrastructure because it is assumed that this government overhead would be in place regardless of incremental changes for individual programs.

Costs assume a cost-plus contracting environment that provides little incentive for contractors to lower labor and material costs.[20] The desired end state is a fixed-price PBL environment designed to encourage cost reductions. In this sense, contractor costs assumed in this analysis may not accurately represent what could be achieved given the right contractual incentives (although there is some limit on the contractors' ability to control costs, given much of the work will be done in government depots). The determining factor in what the approaches cost could indeed be how contractual incentives are structured and implemented.

A change in any of these assumptions could change the outcome of the comparison. Hence, a full-scale business-case analysis to assess the costs of the two approaches more accurately should be conducted relatively soon. The time needed to develop an organic capability means that a later start to the business case analysis will result in a later transition to an organic PSI, if that proves to be the more cost-effective option. However, this point must be balanced by the fact that a later start to the business-case analysis would mean that the program would be more mature and that more insight into future costs would be available. In-depth analyses will enhance the Air Force's ability to understand which approach represents best value for the Air Force and the taxpayer.

Benefits

We also assessed benefits claimed by representatives of the contractors and government sustainment organizations. Although it was not possible to validate and quantify the asserted benefits, if either the Air Force or the contractors could prove to offer superior service, particularly in the form of any metric related to aircraft availability such as not-mission-capable-due-to-supply rates, the value of such benefits could overshadow the cost differences identified in our analysis.

Contractor-asserted benefits come from such initiatives as centralized asset management of spare parts, an integrated supplier base (with other programs), better information systems and databases, integration of supply chain management with engineering, funding flexibility, and the ability of profits to motivate performance. While we judge that some of these are in fact real benefits to the contractor (which can more quickly and flexibly invest in computer upgrades, for example), we were not able to monetize them.

Since the Air Force is pursuing a CLS approach for the F-22, there was no one inside the Air Force who had been assigned the role of advocating for an organic solution. Hence, there was no comparable list of "government-asserted benefits." We note that many of the initiatives that the contractors assert will benefit them can also be adopted by the government, as some have. Other benefits to the government for keeping the work in-house will be the continued development of human capital for managing sustainment, which will help the Air Force meet future congressionally mandated 50/50 and core requirements. Also, if the work is done organically, the Air Force may have more flexibility in taking funds away from sustaining the F-22 if

[20] This assumption represents the current environment for the F-22, which has used yearly cost-type contracts for sustainment.

more urgent fiscal needs arise, which is more difficult if the government has a formal contract with an external provider.

Other Issues

Our analysis also uncovered a number of issues of interest to analysts. One of them involves so-called technical data rights. At the outset of this analysis, the cost of technical data rights was purported to be an important discriminator between the approaches. Further research revealed that *technical data rights* has several meanings; the most relevant definition for this study refers to repair instructions. Because the vast majority of the repair work is taking place at government depots, the government must pay for repair instructions no matter which alternative is selected. There is no strong evidence indicating that a contractor PSI would reduce these costs.

The analysis of the F-22 process for assigning DLR workload revealed that workload assignments were usually already decided because of core or 50/50 requirements. The depot partnering assessments conducted by the SPO were informative but did not appear to affect outcomes.

Organization of This Report

Chapter Two discusses aircraft sustainment and details the PSI role and functions. Chapter Three describes the notional organic approaches, contrasting the personnel needed for managing sustainment activities. It also describes the differences in the direct costs of the two approaches. Chapter Four describes the indirect charges—the fees and surcharges—and how they differ. Chapter Five briefly explains how to compare the two types of charges. Chapter Six outlines the potential benefits offered by contractors and government PSIs. Chapter Seven discusses several related PSI issues, and Chapter Eight provides summary conclusions and recommendations.

Three appendixes present additional issues identified during the course of the research. Appendix A examines data rights issues and their costs. Appendix B analyzes the processes used to assign depot workload, work conducted to respond to a specific task assigned by the research sponsor. Appendix C provides a detailed list of F-22 sustainment activities and identifies those that the Air Force should perform, those that the contractor should perform, and those that either party could perform reasonably well.

CHAPTER TWO

Weapon System Sustainment and PSI Roles

The PSI is responsible for managing a broad range of sustainment activities. However, the PSI management role by itself comprises only a relatively small part of these activities. This chapter defines *sustainment* and provides an overview of sustainment activities, particularly those performed in a PBL environment. In addition, because the PSI management role is at the heart of what could change in the PSI comparative analysis, this chapter also describes the PSI role, provides a detailed list of PSI activities or responsibilities, and discusses what activities will likely remain unchanged by the Air Force's PSI decision.

Defining Sustainment

The F-22 Program Director and other weapon system managers are responsible for a wide range of functions and activities. Much like the overall universe of logistics activities, sustainment has been described in several ways. The Defense Acquisition University defines *sustainment* as

> the supportability of fielded systems and their subsequent life cycle product support—from initial procurement to supply chain management (including maintenance) to reutilization and disposal. It includes sustainment functions such as initial provisioning, cataloging, inventory management and warehousing, and depot and field level maintenance. Sustainment begins when any portion of the production quantity has been fielded for operational use. Sustainment includes assessment, execution and oversight of performance based logistics initiatives, including management of performance agreements with force and support providers; oversight of implementation of support systems integration strategies; application of diagnostics, prognostics, and other condition based maintenance techniques; coordination of logistics information technology and other enterprise integration efforts; implementation of logistics footprint reduction strategies; coordination of mission area integration; identification of technology insertion opportunities; identification of operations and support cost reduction opportunities and monitoring of key support metrics. (Secretary of the Air Force, 2005, p. 58)

According to the Joint Staff, *sustainment* is defined as

> "the provision of personnel, logistic, and other support required to maintain and prolong operations or combat until successful accomplishment or revision of the mission or the national objective" (JP 1-02). It includes the supplies and services needed to support the initial execution of approved [operation plans], an intermediate level of supplies to support the force until resupply is available, and the replenishment stocks necessary to main-

> tain and conclude operations. Theater sustainment management should emphasize velocity and time-definite delivery from [the continental United States] and other sources outside the theater rather than large in-place inventories. (U.S. Joint Chiefs of Staff, 2000, p. I-16)

The U.S. Air Force defines *sustainment* as the Air Force's ability to maintain operations once forces engage. It involves the provision of

> personnel, logistics and other support required to maintain and prolong operations or combat until successful accomplishment or revision of the mission or of the national objective. (Secretary of the Air Force, 2005, p. 58)

A detailed list of F-22 sustainment activities is provided in Appendix C. The tables in Appendix C also indicate which activities would most reasonably be performed organically and which activities would most reasonably be performed by the weapon system contractor regardless of other sustainment choices, as well as which activities would move from contractor to organic if the organic approach were selected.[1] Combined with the depot maintenance and repair functions that must be performed organically to ensure compliance with public laws, the number of sustainment activities that are "in play" is reduced significantly. Appendix C also lists activities that could be performed by either an organic or contractor PSI organization.

In addition to describing sustainment, it also is important to define the PSI function more precisely so an informed comparison can be made between the two different alternatives.

F-22 Product Support Integrator Activities and Responsibilities

This section describes the overall F-22 PSI function, provides a detailed list of PSI responsibilities, and identifies those that could be performed by either an organic or a contractor PSI organization.

Overall Role of the Product Support Integrator

Regardless of whether it is organically supported or sustained by a contractor, every weapon system has a government office responsible for overarching management functions, led by a senior military officer or government civilian who serves as the program manager.[2] The program manager typically delegates responsibilities for oversight and management of the product support function to a product support manager, who leads the development and implementation of the product support strategies and works to achieve the desired support outcomes during sustainment. In turn, the product support manager, while remaining accountable for system performance, effectively delegates responsibility for delivering performance outcomes to the PSI. In this relationship, and consistent with "buying performance," the PSI has considerable flexibility in terms of how the necessary support is provided, so long as the outcomes are accomplished (DAU, 2005, p. 3-14).

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[1] The information on likely locations was based on interviews with several program offices for organically managed programs on activities that they maintained in-house and on discussions with representatives of the contractors, both of which also supported organically managed programs. We vetted this information with the government and with the contractors.

[2] This description of the PSI draws heavily from DAU, 2005, Section 3.2.

The PSI is responsible for integration or management of tasks and does not perform the actual weapon system sustainment tasks, which can be completed by organic or contractor organizations. The PSI provides the direction, coordinates the efforts of people skilled at their sustainment roles, and provides feedback on the overall performance of the entire sustainment group. The PSI's responsibilities can be wide-ranging or narrowly defined, depending on the Air Force program manager's guidance and vision for the PSI.

The PSI integrates all sources of support, public and private, defined within the scope of the PBL agreements to achieve the documented outcomes. Candidates for the PSI of a weapon system include

- the system's original equipment manufacturer (OEM) or prime contractor
- an Air Force or other DoD component organization or command
- a third-party logistics integrator from the private sector (DAU, 2004, Section 5.3.1.5).

For the F-22 program, the contractor PSI would have a contract with the Air Force specifying negotiated levels of performance. The contractor PSI, in turn, would have formal agreements with organizations performing the actual sustainment work, such as depot repair. The contractor PSI manages contracts with private vendors that perform repairs and has formal agreements, such as implementation agreements, with organic depots.

Managing organic organizations as a PSI has some specific challenges because it is difficult to provide either real incentives to improve government performance or real deterrents to avoid bad performance. Furthermore, organic PSIs are not subject to contracts (and contracting law) in the same way as commercial companies. One way to manage this is for program management to formally bind the PSI to achieve performance outcomes through a memorandum of agreement or memorandum of understanding—but both sanctions for nonperformance and possible incentives are limited. Another option to incorporate some of the benefits of PBL is for the PSI to use PBL contracts with OEMs on a system-by-system level.[3] In contrast, contractors are very focused on economic outcomes, so the promise of profits—or the threat of their loss—gives them a significant incentive to perform. However, PBL arrangements with contractors do not necessarily result in savings to the government unless they are effectively negotiated and priced, which can be harder to do in the absence of cost information.

Activities coordinated by the PSI can include, as appropriate, functions provided by organic organizations, private-sector providers, or a partnership between the two. Although product support tasks are performed by numerous organizations, the PSI is the single point of accountability.

The scope of the PSI's responsibility is directly related to the scope of the PBL strategy, which can be implemented across a broad range of responsibilities. In general, PBL can be implemented at any level, from a single support activity (e.g., wholesale supply) for a single component (e.g., fuel control) all the way up to a wide range of support activities, including materiel management, maintenance, transportation, technical support, training, and so on, for a complete weapon system, such as the F-22 aircraft (Cothran, 2005).

In the case of the F-22, the following responsibilities are candidates to be performed by the PSI, regardless of whether it is organic or contractor. The responsibilities are divided into

[3] A 2004 U.S. Government Accountability Office report suggests that this is actually the typical commercial practice, rather than systemwide arrangements.

three major categories: air vehicle and engine depot activities, supply chain management activities, and other product support activities.[4]

Air Vehicle and Engine Depot Maintenance Activities

Plan, track, status report, schedule, manage configurations, analyze costs, and integrate changes of heavy maintenance and modification activities with ALCs and/or contractor sources of repair (SORs). Although there is no programmed depot maintenance for the F-22 at this point,[5] correcting deficiencies or making modifications to the aircraft have and will become necessary over time. A key PSI function is the maintenance of records that indicate the exact configuration of each aircraft. Using that information, any maintenance necessary to bring specific aircraft up to the latest desired configuration must be coordinated with either the ALC or the contractor facility selected to perform the maintenance. When scheduling the maintenance of individual aircraft at the sources of repair, the PSI must consider both the repair facility's capacity and operational requirements to ensure there are enough aircraft available to operational commanders while balancing the constraints of the funding available to finance the repairs.

Manage repairs of DLRs. DLRs are removable parts of the aircraft that, due to their design and high value, are repaired after they fail and are returned to service. Almost all parts on the F-22 are "peculiar," or unique, meaning that they are not used on other aircraft.[6] When a component fails, the mechanic removes it, obtains a new one from the base inventory control point, and installs it on the aircraft, thereby returning the aircraft to operational status. The failed part must be sent to a designated repair facility, where repair experts fix the DLR. The repaired DLR is returned to the supply inventory, where it becomes available for reissue to another aircraft. The PSI must ensure that there is a system to track the reparables, designate SORs ready to perform the repairs, and establish a financial arrangement to reimburse the SOR for all costs involved in the repairs. The SORs could be government depots, OEMs, or third-party contractors.

Manage the maintenance program for air vehicle and engine software. Software maintenance is an ongoing task for any modern, computer-dependent system, the F-22 included. The actual maintenance of the software includes ongoing testing and the correction of deficiencies but often includes minor updates and major upgrades of the software. There are millions of lines of code on the F-22 and on support, health management, and training systems. When major software modifications are required, such as to support the addition of a new weapon, such activity would be separately identified and funded. After development and testing, the new software would be uploaded onto each aircraft and the new configuration recorded.

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[4] These responsibilities are taken primarily from the F-22 Request for Information, dated March 1, 2005, with modifications based on RAND discussions with a wide range of government and contractor personnel working on the F-22 and other weapon system programs.

[5] A definition of PDM can be found in Keating, Resnick, et al., 2008:

> Depot maintenance involves challenging work, such as extensive aircraft disassembly, that is not done at aircraft home installations. Instead, it occurs at specialized facilities such as the Warner Robins Air Logistics Center . . . at Robins Air Force Base in central Georgia. *Programmed* refers to maintenance that occurs on a schedule rather than in response to a specific aircraft's condition.

[6] There are about 18,000 peculiar, or unique, parts and 1,850 maintenance-significant items associated with the F-22 air vehicle.

The role of the PSI is critical in ensuring that either contractor or organic support is in place to perform these tasks in a timely, integrated manner. The PSI would develop requirements based on inputs from Air Force operational commands, estimate funding requirements, provide inputs for the SPO to support efforts to program and budget for funding, award contracts to commercial sources or provide funding to organic sources, monitor performance of these organizations, and provide overall management to all the software support efforts.

Manage modification development, production, and installation activities. As new F-22 operational requirements emerge due to changes in the threat or simply greater operational flying experience, modifications will be required. Unlike software modifications, these modifications result in physical changes to each aircraft after installation. Engineering is required for the development, integration, and testing of each modification. The hardware is then produced and installed on each aircraft, often at a depot facility.

The F-22 has established two depots where modifications can be performed, each with six workstations (docks) designed for unique F-22 air vehicle requirements. One depot is a contractor facility in Palmdale, California, where Lockheed Martin employees conduct the work, and the other depot is at Ogden ALC at Hill AFB, Utah, where U.S. Air Force civilian employees perform the work.

The program's goal is to develop and maintain equal depot-level maintenance capabilities at both sites. The PSI will be responsible for managing all activities required to develop, produce, and install the modifications on all applicable aircraft. This will require coordinating with the operational commands and two depots to properly schedule individual aircraft, as well to as ensure that modification kits are available when aircraft arrive at the depots.

Establish relationships with ALCs to ensure that core and 50/50 requirements are met. The F-22 SPO and the two prime contractors have developed and are implementing plans to ensure that the majority of the F-22 depot-level maintenance will be performed by U.S. Air Force civilian employees under partnerships with either Lockheed Martin or Pratt & Whitney. In some cases, the OEM works through the prime contractor to establish these repair sites at the three Air Force ALCs. The prime contractors and the ALCs have or will develop implementation agreements to serve as substitutes for actual contracts among the parties. Both prime contractors would be responsible for the output of these component repair facilities under PBL contracts with the F-22 SPO, per acquisition policy. As of September 2007, three of these capabilities were in operation, 11 were being developed, and 19 more were planned, for a total of 33 to be implemented by FY 2012. Because the labor is performed by government workers at government-owned facilities using government-owned equipment, F-22 repairs completed under the partnering arrangements count toward the Air Force's compliance with both core and 50/50 requirements. Since establishing these repair capabilities is nonrecurring effort, this PSI responsibility will end after the arrangements are complete, unless something currently unforeseen dictates that new arrangements are necessary.

Supply Chain Management Responsibilities

Forecast demand; establish stock levels; procure, report, and satisfy base requisitions for unique DLRs and consumables; and coordinate common DLR and consumable inventory activities with the

DLA or Air Force.[7] It is likely that the PSI's most demanding responsibility overall is managing the supply chain of every reparable part or consumable supply (excluding fuel and lubricants) required to support the F-22.

The DoD supply system organizes parts and supplies into two broad categories: (1) peculiar, those used on only one weapon system, and (2) common, those used on more than one system. For the peculiar F-22 items, the PSI will be responsible for managing inventories, estimating requirements, ordering items with sufficient lead time, ensuring the availability of items at operational bases to meet the established performance metrics for timeliness and availability, reporting on the availability of items, and ensuring reimbursement by the Air Force. For peculiar reparable items, the PSI must closely coordinate with SORs to ensure that parts are fixed and returned to inventories to satisfy demands at the operational bases.

For common items, the PSI will estimate F-22 requirements and update Air Force or DLA managers of these items. The managers will then merge the F-22 requirements with those of other weapon systems. Examples of some common items include cartridge-actuated devices, propellant-actuated devices, communication security equipment, any government-furnished equipment, and electronic warfare expendables. Although the PSI is not responsible for tracking common items, as it would be for peculiar (unique-to-that-platform) items, the PSI is expected to closely track the inventory of common items to ensure that F-22 aircraft metrics are not adversely affected by a parts shortage.

Coordinate transportation requirements among base-level customers, depots, and other SORs. As in the supply chain management responsibility, the PSI will closely manage the transport of peculiar reparables between operational bases and SORs to ensure that inventory levels are sufficient to meet operational needs. In addition, the PSI will coordinate transportation with sources of supply for peculiar consumable items required at operational bases and repair materials for ALCs working under partnerships.

Determine requirements and manage wholesale activities related to readiness spares packages and other war reserve materials. Readiness spares packages are kits containing sufficient items to support a deployed F-22 unit at a certain level of activity for a specified number of days. These kits are essentially mini-inventories of the consumables and reparables normally found in a base-level supply function. By analyzing usage rates for consumables and break rates for reparable items based on peacetime flying experience, the PSI develops recommendations for the levels of individual items that are included in each readiness spares package, as well as other materials required for sustaining wartime flying at a deployed location. The operational flying units would be responsible for ordering the items and maintaining these kits during deployments.

Other Product Support Activities

Manage other F-22 and F119 product support activities, including the following:

- technical order maintenance and distribution
- sustaining engineering activities
- base-level and depot technical assistance program

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[7] When this research was being conducted, the Air Force and DLA were in the process of transferring most supply chain management responsibilities for all consumable supplies from the Air Force to DLA, with an accompanying transfer of authorizations and people.

- diminishing manufacturing sources analysis and planning
- support to air vehicle–engine integration issues
- fleet health management program
- force/life structural maintenance plan
- force/life management process
- weapon system integrity life management plan
- Aircraft Structural Integrity Program
- aircraft battle damage repair programs.

These responsibilities are wide-ranging, involving the integration of technical support for the F-22. Much like automobile owners' manuals and repair manuals, the Air Force uses technical orders as a means of documenting and standardizing activities ranging from pilot instructions to repair instructions for mechanics at the flight line or depot level. Initial technical order distribution is normally performed by the prime contractor. The F-22 Integrated Management Information System (IMIS) is a highly automated maintenance device with electronic technical data used by maintenance personnel to perform analysis, repair malfunctions, and record repairs made to each tail number for historical records. Maintaining technical orders with the latest information and changes must be managed carefully, particularly because safety is a preeminent consideration in flight operations. This function could be performed either organically or by contractors, but the PSI must manage the effort.

After an aircraft is produced and accepted into the operational fleet, engineering support is still required as previously unseen problems arise or are beyond the technical maintenance capabilities of the operating unit. Regardless of the PSI, some ongoing sustaining engineering support will be required from the prime contractors and major OEMs after aircraft production is ended. For example, Lockheed Martin still provides engineering support for the F-16, an aircraft originally designed in the 1970s. Working in coordination with engineers at home locations, prime contractors and OEMs normally have representatives at operational bases to provide on-the-spot technical expertise as problems arise. Even under an organic PSI, some contractor representation will be necessary at the bases.

Over time, parts may become obsolete or have higher-than-expected break rates, or sources of repair or repair materials may become dated or unavailable as newer technologies replace older ones in the marketplace. As a result, engineering support may be needed to deal with these issues. This support could involve parts redesign to keep up with technology or to reduce the number of repairs, thereby reducing inventory requirements. Engineering support is also necessary to manage the effects of diminishing manufacturing sources over the life of the weapon system, particularly after the end of production, as new sources are located and qualified. Managing these issues is a responsibility of the PSI, regardless of who performs the redesign efforts.

The responsibilities just discussed are all engineering-related support functions that can be performed by organic engineers or by contractor engineers. However, the PSI must ensure that effective programs are in place, decisions are properly made, and changes implemented.

Manage peculiar support equipment, test equipment, and associated spare parts inventories; forecast requirements; establish SORs; and coordinate transportation from procurement or repair through delivery of assets to users. This responsibility is closely related to the management of peculiar reparables, except that it pertains to the array of equipment, tools, and test equipment necessary to maintain the F-22. After initial provisioning at each location, analyses are

required to ensure that spare parts are available for support equipment that can be fixed locally, transportation to a SOR is coordinated, and maintenance and repairs are performed quickly. If a piece of support or test equipment becomes uneconomical to repair, the PSI's procurement process must obtain a replacement quickly.

Coordinate F-22 training systems support, including base-level maintenance, modification planning, and integration with aircraft modifications and courseware updates. The PSI's role is to basically oversee that all training system support is on contract, appropriately funded, and that all requirements are accomplished. AFI 63-111, 2005, requires that all training system support be performed by a contractor.[8] In addition, mobility requirements are not a consideration because training devices need not be deployed during contingencies. Currently, Boeing is responsible for all training device support, from technicians operating training devices at operational and training bases to engineering support to ensure these devices are configured to match the aircraft as they are modified in the fleet. (There have been some changes in the training approach over time. For example, Pratt & Whitney provided flight-line and intermediate engine training to the Air Force under the original contract.)

Coordinate hardware and software maintenance and repair, as well as technical data interfaces, among F-22–unique data and technical order systems and Air Force information technology systems.[9] As a modern, integrated aircraft, the F-22 depends on a wide array of data and data systems. The PSI's basic responsibility is to ensure that the F-22 program and sustainment activities can properly interface with each of the systems; that proper hardware is available within the Air Force at bases, depots, or other locations; and that ongoing efforts are conducted to keep data current in these systems and to modify data and software to ensure that interfaces are current. In many cases, support or prime contractors will actually perform the work. The PSI must ensure that the work is on contract and funded and that efforts are successful.

Develop and justify financial requirements for the F-22 air vehicle and F119 engine as part of the planning, programming, budgeting, and execution process. In conjunction with the F-22 SPO, the PSI will have to forecast financial requirements for all sustainment activities under its purview, develop budget estimates, and provide justification for the funding. As with all systems, budget reductions to the F-22 may be proposed, so trade-offs and possible reductions in funding will have to be analyzed and the impacts of reduced funding explained to decision makers.

Conduct contracting activities with prime contractors, subcontractors, and suppliers, including contract development, source selections, contract administration, and payment activities. The PSI will have to perform all contracting activities related to F-22 sustainment. Currently, the Air Force is responsible for only two major contracting efforts related to F-22 sustainment: the performance-based agile logistics support (PALS) contract with the Lockheed Martin/ Boeing team and the Field Support and Training (FS&T) contract with Pratt & Whitney. Each of these primes, in turn, then establishes and administers the legal requirements between

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[8] The training itself can be conducted by organic personnel:

> Training Devices. Life of system [contract support] is mandatory for all training devices (the term training devices does not include trainer aircraft), unless HQ United States Air Force (USAF), Deputy Chief of Staff, Installations and Logistics, Director of Maintenance has approved a waiver. The [system program manager] is responsible to ensure the [contract support] maintains the configuration for training devices functionally equivalent to the system, equipment or program they serve. (AFI 63-111, 2005, p. 7)

[9] Including IMIS, Joint Computer-Aided Acquisition and Logistics Support, Interactive Electronic Technical Manual, F-22 Information Resource Management, and the Integrated Document Archiving and Retrieval System.

themselves and their subcontractors and suppliers. If the PSI were an organic entity, these ongoing contracting responsibilities would shift from the two prime contractors to the Air Force, leaving the organic PSI to establish and administer many of these subcontractor and supplier contracts, as well as monitor performance and make payments.

Ensure that the maintenance and repair data collection and analysis program, including the logistics supportability analysis program, is viable and meets U.S. Air Force requirements. As maintenance data are collected, an ongoing analysis program determines areas in which greater effort should be placed to increase reliability and/or reduce sustainment costs. Periodic areas of analysis are identified and engineering analyses are conducted. Results can take the form of modifications, changes in maintenance requirements, or other processes by which an aircraft is sustained. Like many other PSI management responsibilities, these analyses can be performed by either contractor or Air Force technical analysts.

Manage the F-22 Raptor Support Center and conference hotel capabilities. The Raptor Support Center offers 24-hour-a-day support to operational units when sustainment problems arise. The center can coordinate whatever support is needed to solve the problem and has Air Force personnel colocated with contractor experts at the Marietta, Georgia, facility. In contrast, other Air Force aircraft have on-call experts who are arranged much more informally. "Conference hotel" is the name given to the capability to quickly link up experts to solve problems experienced by an airborne aircraft. Again, these capabilities are managed by the PSI but can be performed by contractor or Air Force personnel.

Oversee the management, maintenance, and repair of the base-level Air Force Mission Support System and Operational Debrief System. To help pilots plan their missions and debrief results after landing, the Air Force has two systems at the operational squadrons: the Mission Support System and the Operational Debrief System. The automated systems' equipment must be maintained and the software updated to match not only F-22 aircraft configurations; it also must be updated periodically with the latest threat information. Currently, Lockheed Martin has two or three people per squadron who are responsible for maintaining these systems and assisting the pilots. Again, this responsibility could be managed by either a contractor or an organic PSI.

Process and resolve deficiency reports. During F-22 sustainment, if anyone discovers a significant defect related to a specific part or process—particularly one related to a safety-of-flight condition—a report of deficiency is forwarded through appropriate channels to the proper organization to correct the problem. This might include a material, process, or procedure change. Speed is of the essence in many cases, depending, of course, on the severity of the problem. The PSI must ensure that proper procedures are in place not only for the initial reporting but also for the follow-up actions needed to rectify the problem.

Ensure that effective threat analysis, threat database maintenance, and system effectiveness programs are in place, along with a program for low-observable maintenance and the update of the Signature Assessment System and low-observable repair data set; arrange support for range flights; and gather and analyze fleet signature data. One of the F-22's hallmark characteristics, in addition to its cruising speed, is its low-observable nature. Much as with other low-observable aircraft, the PSI must conduct an ongoing program to maintain the signature of each aircraft at the desired level. Hence, a program of assessment and maintenance is required, including periodic flights to the test range to analyze an aircraft's signature. Due to the highly classified nature of the work and the clearances of the personnel involved, it is likely that this function would remain with Lockheed Martin in the near term. Contractors generally have a more

stable workforce (and thus a more stable base of workers with clearances), compared to government and military personnel, who regularly rotate into different positions for career development.[10] However, the PSI must manage the program and be involved in scheduling aircraft on the range and other activities associated with this function.

Conclusions

The PSI is responsible for managing a broad range of sustainment activities. These activities include maintenance and repair, along with a host of management functions. However, the PSI role by itself comprises a relatively small portion of these activities. The PSI is responsible for achieving performance outcomes, and we focus on the PSI because the cost and performance of this function were the subjects of this study.

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[10] These rotations can mean that, by the time they are cleared, military personnel may be nearing the end of their tour. Extra personnel may be required to ensure a sufficient number of cleared staff at all times, adding costs. The background checks themselves are also costly.

CHAPTER THREE

Organizational Responsibilities and the Methodology for Determining Manpower Requirements

The PSI's responsibilities cover a broad range of activities that need to be undertaken regardless of whether the PSI is an organic or contractor organization. However, the design of the PSI organization and the number of personnel involved need not be the same—in fact, will not be the same—depending on which organization is in charge of developing and staffing the PSI.

This chapter begins the process of comparing two approaches, starting with the planned contractors' PSIs. It describes the development of notional organic PSI organizations and describes how existing organically managed programs can serve as templates to ensure realistic PSI alternatives.

This chapter also provides a first look at the complexities of developing a valid cost comparison between contractors and government organizations. It describes in detail the significant differences between the costing approaches that determine whether personnel and functions are paid for as direct charges or funded as indirect surcharges on other costs.

This chapter is divided into six sections:

1. a summary of F-22 PSI activities with an Air Force organizational focus
2. the current F-22 air vehicle sustainment strategy, F-22 air vehicle roles and responsibilities, and forecasted work-years of the Lockheed Martin/Boeing team
3. the current F119 engine sustainment strategy, engine PSI roles and responsibilities, and forecasted work-years of Pratt & Whitney
4. our notional approach for supporting the F-22 with an organic PSI
5. the effect of an organic PSI on forecasted contractor work-year requirements
6. a summary of the methodology of the manpower analysis.

Air Vehicle PSI

This section provides a brief recap of sustainment activities and the PSI's functions, with a focus on where each is conducted. This summary focuses on the requirements and costs of PSI manpower, which is the primary element of F-22 sustainment activities that would change depending on the contractor or organic PSI decision. This summary also helps clarify how the PSI organizations are defined in light of their primary tasks.

We began the analysis of F-22 sustainment organizational activities and manpower requirements with a broad consideration of sustainment activities. Although there are many

ways in which sustainment activities can be categorized, it is useful to consider the activities as base-level, depot-level, and other activities.[1]

Base-Level Activities

The current plan for the F-22 is that all flight-line maintenance and most base-level supply system responsibilities will remain with the Air Force or DLA at the AFBs where the F-22 will be assigned.[2] These base-level functions are usually performed by government personnel. Thus, under either PSI approach, the vast majority of base-level tasks and responsibilities will remain with the Air Force, with no change in the number of people involved with flight-line (on-equipment) maintenance and other support.

In the current PSI arrangement, Lockheed Martin/Boeing and Pratt & Whitney have personnel at each operational base where they provide supply chain management for F-22–unique parts and supplies and perform a host of other tasks, such as on-site field services, F119 intermediate-level repairs, and IMIS management and support.

The Air Force has wide latitude to decide whether most of the off-equipment[3] sustainment tasks, both on base and off, will be performed by military personnel, DoD employees, support contractors, or aircraft/engine prime contractors or their suppliers (OEMs).[4] In some instances, the tasks are fulfilled by both government and contractor personnel. Contractors currently perform many tasks at the base, depot, and other levels. There are quite a few functions (listed in Table C.1 in Appendix C) that would probably not switch from either organic to contractors or vice versa, regardless of the PSI decision. This assessment is based on the Air Force's current approach for fighter aircraft sustainment.

Depot-Level Activities

For depot-level activities, compliance with public law requires that most F-22 depot work be performed organically. However, some F-22 depot maintenance will be performed at the Lockheed Martin Palmdale facility by contractor personnel. Plans also call for both government and contractor employees to conduct software maintenance, which is considered a depot maintenance activity. As was the case with base-level activities, the currently planned mix of organic and contractor depot work will not change regardless of the PSI decision.

Other Activities, Including Engineering and Supply Chain Management

A number of PSI functions, tasks, and responsibilities could be moved to a DoD organization if organic PSIs are implemented for the F-22 air vehicle or F119 engine.[5] Activities that

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1 Appendix C lists some of the major functions required to sustain the F-22. Table C.1 shows the functions, tasks, and responsibilities that would remain the same under either an organic or contractor PSI; Table C.2 shows those that *could* be shifted from the current contractor PSI sustainment approach to an organic (DoD) sustainment approach. The number of functions, tasks, and responsibilities is an indication of the complexity of sustaining a modern fighter aircraft.

2 As of this writing, the current DoD strategy was to transition much of the Air Force and other services' supply chain management responsibilities to the DLA in the FY 2008–2009 time frame.

3 On-equipment tasks are those performed on the aircraft itself, while off-equipment tasks are performed on items that have been removed from the aircraft.

4 The other functions in Table C.1 in Appendix C are shown as they are currently fulfilled by either the government or by the prime contractors or their subcontractors.

5 Activities that could be moved between contractor and organic organizations are shown in Table C.2 in Appendix C.

could change due to the establishment of a different PSI, which represent a minority of manpower numbers and costs associated with total F-22 sustainment, are discussed in the following sections.

Decisions regarding the air vehicle and engine PSIs likely would be made independently, so the following sections consider the methodologies for determining the air vehicle and engine manpower requirements and costs separately. However, because the F-22 is the first aircraft with a totally integrated avionics system in addition to its integrated diagnostics and low-observable characteristics, efforts to distinguish the PSI responsibilities must be carried out with considerable care to ensure that there are clean lines of responsibility for different aspects of sustainment and that operational sustainment responsibilities do not become diffuse and thus potentially degrade the aircraft's combat effectiveness.

Lockheed Martin/Boeing Air Vehicle Sustainment Approach

Since 1995, the Air Force's F-22 sustainment strategy has been to contract with the Lockheed Martin team for virtually all off-equipment sustainment support of the F-22 air vehicle.[6] The team has worked with the Air Force during the last half of the system development and demonstration phase and into the production phase to ensure that sustainment issues were identified and resolved as they were encountered. As a result, both developed a considerable depth of sustainment expertise with the aircraft.

In-depth contractor involvement in the sustainment of a new system has been the norm with most Air Force aircraft. However in the past, contractor involvement was typically treated as a temporary situation, and the Air Force was expected to assume the bulk of the sustainment responsibilities after a few production lots were complete and depot capacity was stood up. These initial temporary sustainment arrangements between the contractor and the Air Force are referred to as "interim contractor support" arrangements.

In the case of the F-22, the Lockheed Martin team's sustainment support was conducted primarily under the PALS contract through CY 2007. The strategy was to initiate a new PBL contract called Follow-on Agile Support for the Raptor (FASTeR) beginning in CY 2008. Because the F-22 system was relatively immature in terms of its accumulated number of flying hours, the FASTeR contract was initially structured to be a cost-plus contract that would be transitioned to a fixed-price arrangement when manpower and material costs had more history and could be better predicted. At that point, the aircraft will be considered mature, with more than 100,000 accumulated flying hours and relatively well-known costs and operational issues. As of this writing, the F-22 was about one-third of the way to that point, with the 100,000-hour milestone expected to occur in 2010.

The F-22 program has made widespread use of the depot partnering arrangements that were made possible by 10 U.S.C. 2474, which has enabled Lockheed Martin to establish agreements with the Air Force ALCs for most of the actual F-22 airframe and component repairs. Under these arrangements, Lockheed Martin subcontracts some of the airframe repair work to the Ogden ALC, where it is performed by government employees. The remainder of the airframe repair work is done at Lockheed Martin's Palmdale facility. Lockheed Martin, in turn, is

[6] In this usage, *air vehicle* includes everything connected with the F-22 program, with the exception of the F119 engine, its controls, and its support equipment.

paid by the Air Force under the PSI contract. (The contractor pays the ALC for the work done there and receives a material handling fee and profit for the work.)

Lockheed Martin also has the nonrecurring task of implementing the majority of the F-22's component repair capabilities at Ogden and the Oklahoma City and Warner Robins ALCs. This arrangement helps the Air Force in its effort to meet the legislated 50/50 goals for depot workload, since work performed by government employees at the depots counts as organic, regardless of who manages the workload.[7] Appendix A addresses the task of assigning depot repair workloads.

Other major air vehicle sustainment activities for which the Lockheed Martin team is responsible include

- supply chain management responsibilities for all unique F-22 reparables (parts that can be repaired and returned to inventory) and consumable supplies (e.g., item management, base-level supply personnel, transportation for parts to and from repair facilities, inventory management, storage).
- program management and integration of sustainment efforts, including all sustainment management activities aside from flight-line (on-equipment) maintenance
- support, maintenance, and modernization of all training devices (primarily a Boeing responsibility) for pilots and Air Force support personnel
- sustaining engineering support for air vehicle issues, including field service representatives at each operational F-22 base
- operation of the Raptor Support Center, which provides 24-hour-a-day technical support to anyone involved with the F-22 worldwide
- maintenance, updates, and collection of data from the F-22 IMIS, as well as maintenance and updates of technical order data
- operational support for mission planning and threat update systems at operational bases.

Under the FASTeR contract, the Air Force and Lockheed Martin will establish performance metrics for various aspects of the program. Part of the award fee that can be earned under the contract will be tied to meeting these performance metrics, thus providing a financial incentive for Lockheed Martin to quickly resolve problems, get parts repaired and back to operational bases, and ensure there are adequate stocks of supplies where needed. Under this PBL approach, Lockheed Martin has significant responsibility, but it also has wide latitude in solving problems (with the limitations inherent in the fact that much of the hands-on sustainment work will take place at government depots, over which the contractors have limited control). Existing contracts have a cost-plus-award-fee structure.

To accomplish the many tasks discussed here, Lockheed Martin's planned work-years of effort were expected to grow somewhat through 2012 as effort increased. F-22s will deploy at two additional bases (Hickam AFB in Hawaii and Holloman AFB in New Mexico), and more depot maintenance workload is required due to additional aircraft deliveries.[8] Lockheed Martin's planned direct labor hours for employees include heavy depot maintenance and modifica-

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[7] 10 U.S.C. 2466 requires that at least 50 percent of the annual depot maintenance workload be performed by government employees.

[8] Current plans call for deliveries through 2011, when production ends, for a total production run of 187 aircraft. One aircraft was lost in a crash in 2009, resulting in an expected fleet of 186 as of this writing.

tions at Palmdale. Government employees performing F-22 maintenance and repair work at the organic ALCs are not direct employees of the contractor and so would not be included in a summary of work-years. (Instead, Lockheed Martin bills them as a material charge to the government.)

Pratt & Whitney F119 Sustainment Approach

The approach for the F119 engine sustainment is similar to that for the F-22 air vehicle. Along with its decision to have contractor support for the air vehicle, the Air Force decided in 1995 to have Pratt & Whitney provide near-total sustainment support for the approximately 450 F119 engines. Pratt & Whitney, like the air vehicle companies, previously has worked with the Air Force on F-22 sustainment issues during the system development and demonstration and production phases. The contract strategy for the F119 was similar to that for the air vehicle, with a cost-plus contract award for CYs 2008 and 2009 and an eventual transition to a fixed-price PBL contract.

Like Lockheed Martin and its depot partners, Pratt & Whitney has developed a partnered depot maintenance capability at Oklahoma City ALC, so almost all depot-level maintenance will be performed by Air Force employees, with Pratt & Whitney responsible for overall management of the engine fleet. Currently, Oklahoma City ALC is fully qualified to perform depot maintenance on the F119 engine modules.[9] Pratt & Whitney's other major responsibilities under the FS&T sustainment contract include

- maintenance services, which include supplying about 15 personnel at operational bases to perform full intermediate maintenance functions and augment organic Air Force flight-line and limited intermediate engine maintenance
- management of F119 support equipment, including procurement and delivery of equipment, fleet management, repair, and inventory control
- maintenance, updates, and collection of engine data from the IMIS, as well as maintenance and updates of technical order data
- fleet management and depot maintenance scheduling
- supply chain management responsibilities, such as requirements determination for parts and consumable supplies, procurement, storage, distribution (item management), and inventory management of spare parts and spare engines
- customer technical support including engineering support, common support equipment systems support, and on-site field service representatives at each of the operational bases.

To accomplish these responsibilities, Pratt & Whitney's work-years are expected to grow slightly through 2010 as final deliveries of the F119 are made and base activations at Hickam AFB in Hawaii and Holloman AFB in New Mexico are completed, and then return to their 2008 level. The number of work-years includes only workers directly employed by Pratt & Whitney, such as touch labor for Pratt & Whitney at AFBs. Government ALC employees per-

[9] Like the F100, and unlike most legacy engines that require the entire engine to be shipped to an SOR for depot-level work, the F119 is broken down into five major modules at the operational bases, and only modules requiring repair are shipped to the depot.

forming direct maintenance labor on the F119 engine would not be included in totals of direct labor because they are not employees of the contractor. (Instead, Pratt & Whitney bills them as a material charge to the government.)

How Would the Air Force Support the F-22 with an Organic PSI Concept?

As stated previously, the Air Force decided in 1995 to use contractor sustainment for the F-22 over the life of the system. Thus, with no organic F-22 PSI organization, procedures, or locations either proposed or reality, we conducted many interviews with Air Force and contractor sustainment managers to determine which sustainment responsibilities would likely be transferred to an organic PSI, designed notional organizations that could fulfill the organic PSI responsibilities, and forecast the number of work-years and personnel required to populate these notional organizations.

Based on these interviews, organizations supporting the F-16 and the F100 engine at the time of our research were considered the best analogies for the notional F-22/F119 sustainment approaches: the 508th Aircraft Sustainment Group (ASG) at Hill AFB (part of Ogden ALC), the 518th Combat Sustainment Squadron (CBSS, also at Hill AFB), and the 540 CBSS at Tinker AFB (part of the Oklahoma City ALC).

Using the military, civilian, and support contractor manpower authorizations of these organizations as the baseline, we worked with these organizations to delete authorizations not required for the F-22 or F119, such as personnel responsible for foreign military sales, and added manpower authorizations for F-22–unique workload, including low-observable requirements. Authorizations also were added for contracting and financial management functions that were not already included in the organizational responsibilities of the three baseline units. As a result, three notional F-22 sustainment organizations were designed, each of which would include a typical mix of military, civilian, and support contractors:

- 22 ASG, located at Hill AFB
- 22 CBSS, also located at Hill AFB
- 119 CBSS, located at Tinker AFB.

22nd Aircraft Sustainment Group (Notional)

The 22 ASG would be responsible for a wide variety of organic sustainment tasks:

- air vehicle depot heavy maintenance and modification planning
- sustaining engineering management
- management of all peculiar support equipment
- coordination with item managers and requirements planning for common support equipment
- coordination, management, and contract administration of data collection and analysis, including logistics support analysis, affordability analysis, technical orders, time compliance technical orders, diagnostic health management, and IMIS activities
- management of software maintenance

- coordination and management of the Raptor Support Center, Air Combat Command Logistics Support Center, mission support planning, and operations support planning
- contract management of training systems support
- management of air vehicle and engine issues
- management of planning, programming, and budgeting requirements for F-22 air vehicle sustainment.

We developed an estimate of the number of Air Force personnel needed to perform these tasks. We estimate that the 22 ASG would add about one-half of the necessary authorizations in one year and the other half in the following year, reflecting the likely inability of the Air Force to stand up a new organization and hire or transfer the necessary personnel in only one year.

Because some of the current sustainment responsibilities are being performed by the 478th Aeronautical Systems Wing (the F-22 SPO) in Air Force Materiel Command (AFMC)/ Aeronautical Systems Center, the F-22 SPO estimated that some of the SPO's authorizations could be transferred to the notional 22 ASG, so fewer new authorizations would be required for the 22 ASG.

22nd Combat Support Squadron (Notional)

The 22 CBSS would be responsible for all supply chain activities related to the F-22 air vehicle, including

- comprehensive air vehicle wholesale supply chain management for[10]
  - peculiar DLRs
  - replenishment spares
  - peculiar consumables
- coordination of packaging, handling, and transportation
- forecasts and coordination of common consumable and DLR requirements
- management, analysis, and support integration of diminishing manufacturing sources for air vehicle components
- requirements determination and wholesale management of readiness spares packages
- processing and resolving quality deficiency reports and production quality deficiency reports
- supporting AFMC Commodity Councils for F-22 component workloads.

We developed an estimate of the number of Air Force personnel needed to perform these tasks. We assume that the 22 CBSS would add one-half of the additional needed authorizations in one year and the other half in the following year, reflecting the Air Force's likely inability to establish a new organization and hire or transfer the necessary people within only one year. Unlike the 22 ASG, the authorizations in the 22 CBSS would be paid on a reimbursable basis from the Material Support Division's revolving fund dollars, as discussed in greater detail in Chapter Four.

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[10] The DLA purchases and manages F-22 consumables and purchases F-22 reparables that the Air Force manages.

119th Combat Support Squadron

To provide organic PSI support for the F119 engine, the notional 119 CBSS would be established at Tinker AFB. Unlike the typical Air Force approach to air vehicle sustainment, in which two organizations are responsible for various aspects of the air vehicle, engine sustainment is normally the responsibility of one organization, so the responsibility list is longer for the 119 CBSS than for the 22 CBSS. These responsibilities include

- planning F119 depot maintenance
- planning, tracking, maintaining status reports, scheduling, and integrating changes
- administering configuration management and tracking
- managing and coordinating diagnostics and health management or IMIS with the air vehicle PSI organization
- managing peculiar support equipment, including associated spares and maintenance (actual equipment repair would stay with Pratt & Whitney)
- providing depot field team planning
- managing and administering F119 data collection and analysis, including logistics support and affordability analyses
- managing and administering F119 sustaining engineering
- managing F119 software maintenance and administration
- managing and administering technical orders
- managing planning, programming, and budgeting requirements for F119 sustainment
- coordinating and scheduling F119 shipments
- providing supply management, including forecasting, establishing stock levels, contract management, purchasing, inventory, transportation, and satisfying base-level requisitions of peculiar DLRs, components and accessories, and peculiar consumables
- coordinating and managing both ALC and OEM SORs
- forecasting and coordinating F119 common consumable and DLR requirements with the DLA
- managing, analyzing, and supporting integration of diminishing manufacturing sources for F119 components
- providing requirements determination and wholesale management of F119 portions of readiness spares packages
- supporting the Marietta F-22 Technical Support Center[11] on F119 issues
- processing and resolving F119 Quality Deficiency Reports, Production Quality Deficiency Reports and Software Deficiency Reports.

We developed an estimate of the necessary number of Air Force personnel. As with the organic air vehicle organizations, we estimate that one-half of these authorizations would be added in one year and the other half in the next year, reflecting the likely inability of the Air Force to stand up a new organization and hire or transfer the necessary people in only one year. As with the 22 CBSS, the authorizations in the 119 CBSS would be paid on a reimbursable basis from the Material Support Division's revolving fund dollars, as discussed in greater detail in Chapter Four.

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[11] The Technical Support Center is the contractor portion of the Raptor Support Center.

Estimating Work-Year Costs

In order to develop consistent cost estimates for each of the three notional organic organizations described here, we applied the same work-year cost methodology to all three organizations. The organizations are composed of a mix of military, government civilian, and contractor workers.

Military work-year costs include base pay, retirement pay accrual, military health care accrual, a basic allowance for housing, incentive special pay, miscellaneous, and permanent-change-of-station costs (including moving costs). The fully accelerated cost was taken from AFI 65-503, Attachment 19-2 (2006). Average rank matches that of military personnel in comparable existing sustainment organizations.

Civilian work-year costs include locality pay; additional variable payments for overtime, holiday, night differentials, incentive awards, and all other personnel compensation above the basic rates paid directly to civilian employees; and government costs for civilian employee benefits, such as retirement and health benefits, life insurance, and quarters or uniform allowances. The fully burdened cost was taken from AFI 65-503, Attachment 26-1, 2007.

All government labor costs were inflated at the rates provided by the DoD Comptroller, so FY 2010 costs are in 2010 then-year dollars, for example. In addition to the salary, fringe, and funded and unfunded retirement costs from AFI 65-503, we added an additional amount per person for travel and other variable costs. Each organization's military, government civilian, and contractor work-years were multiplied by the appropriate cost per work-year (as described earlier) to allow us to estimate the organization's labor cost.

To determine contractor work-year costs, we used forward pricing rate agreements provided by the contractors (agreed-upon rates to cover work done at a particular facility for a defined period).

Impact of Organic PSI on the Lockheed Martin Team and Pratt & Whitney

If the Air Force adopts an organic PSI strategy, the contractors' current or forecasted PSI workforces likely would be reduced or eliminated. The workforce forecasts provided by Lockheed Martin and Pratt & Whitney were broken down in great detail, either by work-hours or by equivalent "heads" into specific work breakdown structure elements or responsibility areas.

We analyzed each area in which responsibility could transfer from the contractors to the Air Force PSIs, based on the responsibilities listed earlier. Because the PSI is primarily a sustainment manager and integrator, rather than a performer of sustainment tasks, there are two major task areas in which contractor workforce reductions would occur: depot maintenance planning and supply chain management activities.

Because of the F-22's complexity, few of the very technically oriented support responsibilities were likely to be transferred from the contractors, particularly with the integrated nature of the F-22 avionics and the unique nature of the IMIS. This is consistent with the Air Force's sustainment approach, with its organically supported, legacy aircraft, which requires significant contractor involvement in postproduction support.

In addition, as mentioned previously, it has already been decided that the majority of the depot-level repairs will be made at the ALCs by Air Force employees. None of the depot-level

workload, and likely little other repair workload assigned to the OEMs,[12] would be affected by the PSI decision.

As a result, the following responsibilities would remain with the contractors,[13] even under an organic PSI approach:

- depot partnering activation responsibilities (a nonrecurring workload)
- field service engineers and field service technicians
- Technical Support Center operation
- significant sustaining engineering activities
- technical order data development, management, and distribution
- IMIS and F-22 information resources management integration and operation, including proprietary data systems
- support equipment development
- all training system support and modification
- engineering, design, kit production and management, and coordination of installation for aircraft modifications
- time compliance technical order incorporation into work packages
- supporting roles in requirements determination and analytical condition inspections
- low-observable signature assessment and repair data collection and analysis.

Despite the many responsibilities that would remain with the contractors under an organic PSI, the Lockheed Martin/Boeing team is expected to lose a number of work-year authorizations if some air vehicle PSI responsibilities are transferred to the organic PSI. Pratt & Whitney would see a reduction in F119 work-years if the 119 CBSS were stood up and assumed PSI responsibilities.

To estimate the cost of the work-year differences, we divided the contractor work-year reductions evenly between two years at the end of the transition period. This staggered reduction of the contractor workforce, coupled with an increase in organic work-years, would allow adequate overlap as the PSI responsibilities are transferred from the contractors to the organic PSI organizations. Thus, the organic PSIs would have full responsibility for PSI execution in the last year of the transition period.

This one-year overlap needed to transfer PSI responsibilities would essentially be a nonrecurring cost due to the overlapping manpower costs: Little additional material costs would be required for the transfer. The reduced contractor work-years were priced using the forecasted or negotiated forward pricing rate agreements for each of the three contractors for each of the areas involved, as the rates varied somewhat by activity area.

Summary of Manpower Analysis

This chapter discussed the methodology used to assess direct personnel costs of a PSI. With a contractor PSI, direct personnel costs are are explicitly identified as labor costs charged directly

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[12] The depot workload planned for OEMs is generally reserved for cases in which the anticipated workload will be small and it would be cost-ineffective to stand up an organic repair capability.

[13] There might be cases in which some small portions of these workloads become organic, but these cases are unpredictable. Thus, for this analysis, we assumed that the workloads would remain with the contractors.

to the sustainment contract. Most contractor labor is a direct charge, except for some vendor managers. Comparably, some government PSI personnel would be directly funded using appropriated funds, i.e., personnel in a notional aircraft sustainment group organization.

Because of the F-22 program's immaturity, the Air Force would greatly benefit from a more detailed analysis of both contractor and Air Force responsibilities and manpower requirements, to be conducted when the F-22 reaches program maturity in 2010 and when steady-state sustainment requirements are better known.

CHAPTER FOUR

Approach for Assessing Material and Surcharge Costs

This chapter discusses the methodology used to estimate PSI costs other than direct labor, including material costs, indirect labor costs, and nonlabor costs associated with the key PSI function of supply chain management. Material costs addressed here are for consumable parts, depot-level repairs, replenishment spare parts, and depot-level modifications and heavy maintenance.

Surcharges, or mark-ups, are costs that would be assessed on that material under either PSI approach. This chapter provides a detailed explanation and discussion of the differences in how a contractor would assess surcharges versus an organic PSI. Surcharge rates or fees across the two approaches are not directly comparable, so an adjustment must be made to enable a fair comparison. This chapter also explains the adjustments made to derive comparable results for material and surcharge costs.

Material Costs

Material costs are those that are specific to the maintenance of the weapon system. This analysis considers four categories of material costs: consumable supplies, replenishment spares, depot-level reparables, and modifications and heavy maintenance.

Consumable supplies include

> material consumed in the operation, maintenance, and support of a primary system and associated support equipment at the unit level. . . . Examples include consumables and repair parts such as transistors, capacitors, gaskets, fuses, and other bit-and-piece material. (Office of the Secretary of Defense, 1992, pp. B-3–B-4)

Consumable supplies are items that are removed and replaced, rather than repaired. They also include small items used in the repair of reparable components.

Replenishment spares are spare parts used to replace parts that have been condemned rather than repaired and to increase stock levels when too few spares were bought initially.

Depot-level reparables are spare parts capable of being repaired at the depot rather than at the unit or organization level: "DLRs may include repairable individual parts, assemblies, or subassemblies that are required on a recurring basis for the repair of major end items of equipment" (Office of the Secretary of Defense, 1992, p. B-4).

Modifications and heavy maintenance are two types of work normally performed at the depot. Modifications include

> hardware and software updates that occur after deployment of a system that improve a system's safety, reliability, maintainability, or performance characteristics to enable the system to meet its basic operational requirements throughout its life. (Office of the Secretary of Defense, 1992, pp. 6-13–6-14)

The F-22 does not have regularly scheduled overhaul or rework, but heavy maintenance would include extensive maintenance or repair, such as repair of fatigue or corrosion damage to the airframe.

Estimating Material Costs

We relied on contractor estimates for all F-22 and F119 material costs. To develop an estimate for modification and heavy maintenance work at Ogden ALC, we relied on data from Lockheed Martin, which provided labor-hour and material cost estimates for modification and heavy maintenance work at its Palmdale, California, facility through 2012. Because depot work is planned to be split between Palmdale and Ogden ALC, it was assumed that the same number of labor hours would be required at both facilities. Using that labor-hour estimate, we developed the material cost estimate by multiplying the labor hours with the escalated special depot wrap rate negotiated between Ogden ALC and Lockheed Martin for F-22 depot work in FY 2006, and then adding the cost of materials estimated by Lockheed Martin. A major assumption in the analysis is that the four categories of material costs will be the same under either PSI approach—organic or contractor. The estimates offered by the contractors for these material costs are assumed to be reasonable and accurately reflect what will be required to sustain the aircraft. Because we found no evidence to indicate that either a contractor or organic PSI would more effectively manage or reduce material costs, we assumed that the material costs would be the same no matter who managed the program. Organic depots will undertake the vast majority of F-22 depot-level repairs, and modification and heavy maintenance work will be split roughly in half between the Lockheed Martin facility in Palmdale and the organic depot at the Ogden ALC, regardless of the PSI. We further assumed that the level of item failures and, hence, the number of consumable items, replenishment spares, and repairs required will not be altered by the PSI decision. (However, if one or the other alternative PSIs could make reliability improvements, then there would be a difference, though this cannot be predicted in advance.) Although these material costs are assumed equal under either PSI scenario, they are shown in the analysis because they provide the basis for calculating surcharges, which are discussed next.

Surcharges

Surcharges are costs that are generated as factors of other costs. The material costs described here are burdened with additional surcharges that represent the costs of managing the material as well as profits earned by the contractors, among other things. Surcharges are assessed on material under both PSI approaches—contractor and organic. However, surcharge rates or fees are not directly comparable for the two approaches, since they pay for different things, so it is important to understand the differences, which we describe in some detail in this section.

Contractor Surcharges

Although their rates are somewhat different, both Lockheed Martin and Pratt & Whitney assess surcharges similarly. Both contractors use a "material wrap rate" or "material burden" to cover the indirect costs of managing materials, such as vendor management. These contractor material wrap rates are assessed on the value of all material managed (i.e., consumable parts, replenishment spares, depot-level repairs, depot-level modifications, and heavy maintenance). It should be noted that contractor surcharges apply to work conducted at the organic ALCs under the public-private partnership agreements, as well as on work conducted at contractor facilities.

Organic Surcharges

The organic surcharge approach is quite different from the contractor approach. First, it is important to understand some background about government surcharges, including the use of working capital fund activities.

Background on the Working Capital Fund. Air Force supply management is a working capital–funded activity, which means that an organic PSI would use surcharges on the value of the material to recover the costs of managing the supply chain, including the labor costs. This contrasts with the direct labor charges for supply chain management personnel under the contractor PSI approach. The following subsections briefly describe supply management under the working capital fund system and two surcharges relevant to the analysis. Although the second surcharge, the material cost recovery rate, is not used in these calculations, it is described because its effect on material management in the Air Force has implications for the F-22 program and the Air Force in general.

Supply Management in the Working Capital Fund. Supply chain management in the Air Force is provided by the Supply Management Activity Group (SMAG) under the working capital fund system. These supply management services include requirements forecasting, item introduction, cataloging, provisioning, procurement, repair, technical support, data management, item disposal, distribution management, and transportation.[1]

The SMAG is composed of four divisions: Material Support Division, General Support Division, Medical-Dental Division, and the U.S. Air Force Academy Division. The Material Support Division, the only division relevant to this analysis, manages the DLRs and consumable items for which the Air Force is the inventory-control point. After AFMC procures the items, the Material Support Division manages them, accumulates the costs of the management or overhead, and recovers those costs through surcharges.

An organic PSI would pay the SMAG Material Support Division two surcharges to recover the cost of supply chain management. These surcharges are the business operations cost recovery (BOCR) rate and the material cost recovery (MCR) rate, both of which are described next.

Business Operations Cost Recovery. Supply management business operation costs include labor costs of item and equipment managers and support personnel, including engineering, contracting, and budgeting. Business operations costs also includes nonlabor costs, mostly in the form of purchased services from the Defense Information Systems Agency and DLA for communication and data services and warehousing functions. These costs are totaled, and the

[1] An overview of the Air Force working capital fund system, supply management functions, and the projected costs through FY 2009 can be found in U.S. Air Force, 2007. SMAG functions are described on p. 19.

yearly BOCR rate is calculated by dividing business operations costs by the yearly cost of consumable and reparable items.

The BOCR surcharge is added to the cost of consumable and reparable items and paid by the customer. In this way, the working capital fund recovers the cost of its business operations in the price charged to its customers. The Air Force strives for stability in its working capital fund rates, but BOCR rates vary from year to year.

Under current organic approaches, the BOCR rate is applied to the sum of consumable parts and depot-level repair ($CP + DR$). No BOCR surcharge is assessed on replenishment spares (RS) or depot maintenance (DM). In contrast, the contractors apply material surcharges (material wrap and profit rates) to $CP + RS + DR + DM$. Whether the contractor or organic surcharges would be greater will be a function of these terms' values.

Note that the cost as calculated by the BOCR rate does not automatically imply that Air Force supply chain management costs for the F-22 would increase by that amount. As discussed in Chapter Three, an organic PSI would require additional personnel whose costs would be recovered by the BOCR. The additional personnel in the combat sustainment group would include item and equipment managers who would be supported by engineers, budget personnel, and contract administrators. There could also be additional organic distribution, storage, and transportation costs, although this would be limited. Much of the sustainment activity would not change under either alternative.

It is problematic to determine the increment of support personnel, warehousing, and transportation costs attributable to the F-22, however. Whether the actual cost change would be less than, equal to, or more than the cost as calculated by the BOCR rate is unknown. Therefore, it is assumed that the BOCR surcharge is a reasonable surrogate for the incremental organic supply chain management costs that would be incurred by an organic PSI for the F-22. Furthermore, the F-22 and F119 programs represent relatively small workloads when considered in light of total Air Force activities covered by this surcharge. It is unlikely that these additional F-22 workloads would alter the BOCR calculation enough to affect the Air Force–wide BOCR average significantly, so we assume that the BOCR would not change.

As a result, this analysis relies on the Air Force's current methodology for estimating and recovering the costs of business operations and assumes that incremental organic PSI administrative costs are a function of consumable parts and repair costs, with no incremental costs associated with replenishment spares, depot-level modifications, and heavy maintenance.

It should be noted that the DLA is in the process of assuming responsibility for the purchasing of all DLRs and consumables—a transition that should be completed by 2012. Because it is unknown what effect the transfer of this responsibility will have on the future BOCR rate, it is assumed that the DLA rates in 2012 will be similar to the current Air Force BOCR rates.

Material Cost Recovery. Although ultimately not used in this analysis, the MCR surcharge is discussed because it is the basis for an insight that could be of interest to analysts conducting similar work in the future.

The Air Force uses the MCR surcharge to fund the cost of buying replenishment spare parts, primarily to replace those that cannot be economically repaired and are condemned but also to adjust stock levels to support readiness. The surcharge is calculated as the cost of items expected to be condemned and changes in stock levels divided by the total cost of repairs across the entire Air Force. This single, Air Force–wide surcharge is applied to the cost of repair for each reparable item in the Material Support Division inventory for all weapon systems.

The MCR surcharge enables every Air Force program to pay the same percentage surcharge on reparable items, which funds the cost of all replenishment spares across the Air Force. Programs that require fewer or less expensive replenishment spares than the Air Force average essentially subsidize programs that require more or more expensive replenishment spares. As a result, the actual replenishment spares costs of any particular program are obscured because they are dispersed across all Air Force programs through the MCR surcharge.

The MCR smoothes customer expenditures and can be thought of as a form of insurance, helping to prevent unexpected replenishment spares bills. It also offers a way for the Air Force to cover the costs of replenishment spares without engaging in more detailed cost accounting on a program-by-program basis. Like the BOCR rate, MCR rates vary from year to year.

This average MCR rate could be used to estimate a program's replenishment spares costs, given an estimate of repair costs. Using the average MCR rate as a baseline, the amount that the F-22 SPO would have to pay in the final year of the transition for air vehicle replenishment spares under an organic PSI approach is very close to Lockheed Martin's estimate of what the SPO would pay in that same year under a contractor approach.

In contrast, Pratt & Whitney's estimate for the final transition year for replenishment spares for engines is much higher than the Air Force MCR rate because Pratt & Whitney expects the actual replenishment spares necessary to maintain F119 engines to be much higher than the Air Force–wide MCR average. This is typical for engines and is not unique to the F119.

Due to the high-performance, high-stress nature of fighter engines, their parts are condemned and replaced more often than aircraft parts on average, and they have much higher rates of replenishment spares costs than the Air Force average. The F100 and F110 fighter engine programs are identified separately in the budget and illustrate this point.

Because this analysis is concerned with demonstrating the actual cost to the Air Force rather than the MCR-based subsidized cost to the F-22 program alone, we discarded the MCR methodology and used the contractors' estimates of replenishment spares costs under both the contractor and organic PSI scenarios.

Engine Part Purchases Under an Organic PSI Case

Commonly, in engine part procurement, the government develops a relationship with a prime contractor, which supplies vendor parts from a prenegotiated price list. The cost includes the prime contractor's fee and cost of vendor management. The estimating procedures described here assume that the government would be able to develop its own relationships with tier 1 vendors and therefore would not pay Pratt & Whitney any additional surcharges for procurement of this material.

To allow for both possibilities, the organic PSI costs are presented in two ways: one as if the government had direct relationships with vendors and one in which it orders all parts from a Pratt & Whitney–managed price list. The reality may be somewhere in between. We note that Lockheed Martin did not make the same argument as Pratt & Whitney regarding the use of a prenegotiated price list as a way of "one-stop shopping" for government procurement of air vehicle parts through the prime contractor. However, to maintain equality in how we treat the two cases, the air vehicle organic PSI results were calculated with and without more costly replenishment spares to make it most comparable to the engine case.

Conclusions

We calculated that, in both the contractor and organic PSI cases, consumable, depot-level repair, and modifications and heavy maintenance costs are the same; we assume that none is affected by the PSI's identity. We also calculated total nondirect labor costs across the two PSI options. It is important to emphasize that these costs are not directly comparable because they contain different activities under the two approaches. That is, the contractor costs omit directly funded supply chain management personnel, who are included in the organic total.

For the analysis of the annual material and surcharge costs for the engine PSI, based on 2012 cost and surcharge estimates provided by Pratt & Whitney, we developed estimates for the annual material and surcharge costs under the organic PSI option with the contractor PSI annual material and surcharge costs.

Again, it is important to emphasize that these costs are not directly comparable because they contain different activities under the two approaches.

Replenishment spares are a much larger proportion of material costs for engines than for the air vehicle. The proportion of spares costs for the F119 engine is far higher, so the program's MCR payments would be only a small fraction of its actual replenishment spares costs. Therefore, we use the contractor estimate as the more realistic cost under both alternatives.

Chapter Five describes the methodology used to ensure that the organic and contractor approaches can be compared accurately.

CHAPTER FIVE

Cost Comparison Summary

As detailed in previous chapters, it is a complex task to accurately compare contractor and organic approaches to managing F-22 sustainment. Developing the comparable organizations is only a first step. To conduct a sound cost estimate, it is imperative to ensure that all appropriate costs are captured and none are double-counted. Chapter Three described CY 2012 direct labor cost differences between the two approaches. In Chapter Four, we compared material and surcharges for the air vehicle and engine, respectively. Individual cost categories under the two approaches (i.e., direct labor and surcharges) are not directly comparable, so a summation of all the varying categories is needed in order to develop comprehensive estimates that are comparable across approaches. This chapter summarizes the approach used for the cost comparison.

The majority of government costs are in the form of surcharges, which change from year to year. Surcharges in 2012 and beyond could deviate from the rates used in this analysis. In addition, it is unknown at present how the surcharges will be affected when DLA assumes more supply chain purchasing responsibilities by 2012 and establishes a new rate for the larger supply chain management organization.[1]

In addition, surcharge rates were applied to estimates of material costs that are unconstrained by budget limitations and based on an immature program. Future budget constraints and growing program knowledge could significantly alter these projected material costs.[2]

Another important difference to note is that contractor labor rates are fully burdened with overhead and other costs. Even the burdened government labor rates used in this analysis do not capture all of the overhead costs associated with operating all three proposed organic sustainment organizations required for the F-22. A contractor's labor rate includes the contractors' expenses for property, buildings, other infrastructure, and interest, but the government owns and has already paid for equivalent resources. Organic labor rates are typically not burdened with the overhead costs of government property, buildings, and other support infrastructure because it is assumed that this government overhead would be in place regardless of incremental changes for individual programs.

Our analysis assumes a cost-plus-fee contracting environment that provides little incentive to contractors to lower labor and material costs. The desired end state for F-22 sustainment

[1] A rationale for moving reparable purchases to the DLA was to realize savings from consolidating purchasing activities. Whether savings would actually be realized is unknown.

[2] Budget constraints may or may not have similar effects under the two approaches. Contractors logistics support contracts sometimes include significant, fixed "must-pay" portions for a level of support that the government has committed to purchase. There may be fewer restrictions to reducing funding for organic programs. See Boito, Cook, and Graser, 2009.

is a fixed-price PBL environment in which contractors are motivated to find cost reductions. The theory behind the PBL approach is that cost control will lead to greater profit margins for the contractors in the near term. If contracts are carefully structured, profits or savings can be shared in some proportion between the contractor and the government. The goal is that savings (in the form of either negotiated lower contract costs or avoidance of contract cost growth) will accrue to the government when follow-on contracts are negotiated. (However, we were unable to find data proving that this has been done effectively, perhaps because PBL arrangements are relatively new.) If the PBL approach proves effective in generating eventual shared savings, the contractor cost estimates may be different from what could be achieved with optimal contractual incentives in place. The determining factor in terms of what the approaches cost would be how contractual incentives are structured and implemented.

Finally, as noted earlier in this report, other costs were identified as potential discriminators between the organic and contractor approaches. Most significant among these are data rights costs. However, because this analysis is concerned with data rights for repair instructions for work done at the depots, those costs should be much smaller than previously suggested. Furthermore, those repair instructions will be essential under either approach so that touch-labor employees have access to the required information to perform the necessary repairs. A more detailed explanation of data rights can be found in Appendix A.

Finally, we note that significant changes in any of these assumptions could potentially change the outcome of the PSI cost comparison.

CHAPTER SIX

Potential Benefits of Alternative Approaches

Previous chapters described the methodology used to compare the costs of the planned F-22 contractor PSI to a prospective organic PSI. However, cost should not be the sole criterion to discriminate among PSI approaches. The lowest-cost provider does not necessarily represent the best value for the Air Force. The F-22 provides an important capability for the nation, and the relatively small size of the fleet means that aircraft availability is a key attribute of the F-22's value. The Air Force is using PBL for the F-22 to try to motivate high levels of logistics performance. The PSI is responsible for managing the F-22 sustainment enterprise and for achieving this performance. It might be worth paying more for a PSI that is better able to achieve valuable outcomes. But how can the benefits of contractor and organic PSIs be assessed and compared?

This chapter attempts to answer that question through a three-step process. First, a brief review of the PBL concept identifies metrics of interest for logistics performance. Second, two logistics metrics that can be monetized are identified, and the methodologies for quantifying the monetary value of the performance are explained. Third, the potential benefits that affect performance are assessed.

Ultimately we find that some differences in benefits between the approaches can be asserted but not quantified. The contractors were forthcoming in providing information on their performance capabilities. However, we were unable to independently verify the claimed contractor performance advantage through logistics databases or other means. Furthermore, the notional organic PSI alternatives did not have champions advocating for them or providing information, so part of this effort entailed investigating the performance of organic sustainment organizations. Thus, this chapter addresses *potential* benefits that could be achieved with different PSI approaches, without speculating on the likelihood of actually achieving them.

Performance-Based Logistics as Context for Assessing Benefits

DoD guidance mandates the use of PBL to support weapon systems. DoD Directive 5000.1, 2003, p. 7, directs that program managers "shall develop and implement performance-based logistics strategies that optimize total system availability while minimizing cost and logistics footprint." Air Force guidance similarly directs the program manager to use PBL to increase readiness and reduce cost and states that readiness may be expressed by system availability or mission-capable (MC) rates (AFI 63-107, 2004).

PBL implementing guidance emphasizes the use of PSIs to manage all sources of logistics support to meet negotiated performance outcomes.[1] Performance outcomes should meet warfighter needs and may be negotiated at various levels of detail, but they should be consistent with the following five metrics:

- operational availability
- operational reliability
- cost per unit of usage
- logistics footprint
- logistics response time (DAU, 2005, pp. 2–5).

The Air Force has initiated a balanced-scorecard capability to assess logistics performance that uses many of the same metrics. The balanced scorecard includes measures of aircraft availability and various types of not-mission-capable-status; measures of maintenance activities, such as flow days and due-date performance; and measures of logistics response time, such as customer wait time or "the total elapsed time between the issuance of a customer order and the satisfaction of that order" (DoDI 4140.61, 2000, p. 2).

The performance work statements in the prospective Lockheed Martin and Pratt & Whitney sustainment contracts for 2008 to 2012 are consistent with the DoD guidance to use PBL and include performance objectives and metrics that are consistent with the five key metrics listed earlier. In particular, the contracts include performance objectives and metrics for operational availability and reliability (F-22 SPO, 2007b; *Award Fee/Performance/Surveillance Plan*, 2007).

A review of the key logistics performance metrics emphasized by DoD, the Air Force, and the F-22 program provides a useful context for assessing potential benefits of the F-22 PSI. In an examination of benefits claimed by the contractors or government organizations, we found that each of the asserted benefits had a logical relationship to at least one of the key performance metrics emphasized by DoD, but the complete or likely value of the benefits could not be measured readily. For example, Lockheed Martin provided examples of cost savings achieved through improvements in parts reliability. Although it is possible to quantify measurable cost savings for individual initiatives to improve reliability, it was not possible to determine the overall value associated with Lockheed Martin's efforts to improve parts reliability by serving as the PSI. Furthermore, what this demonstrates is the *possibility* of reliability improvements through appropriate investments. These improvements could occur under either approach, no matter who made the investments. In this case, the SPO may have provided the funds necessary to develop and implement the improvements.

This example illustrates the difficulty in determining the monetary value of benefits associated with a PSI. The next section explains an approach to valuing benefits.

An Approach to Valuing Logistics Performance

In valuing asserted benefits, we looked for a relationship between benefits and logistics metrics of interest. For example, a PSI's asserted benefit of the use of expedited shipping of parts

[1] See, for example, DAU, 2005, Chapter 3, Section 2.

would be related to the metric of logistics response time. Then, the challenge was to value that measure of logistics performance. We were able to suggest a method to monetize, indirectly, the metrics of reliability and logistics response time through their contribution to the requirement for spare parts. We were able to monetize one logistics metric directly—operational availability—by devising a way to value MC hours.

Valuing Logistics Response Time and Reliability Through Requirement for Spare Parts

This section attempts to demonstrate the economic value of the potential benefits of the two approaches. Here, we address the potential for the PSI to achieve shorter logistics response times and thus reduce the requirement for spares.[2] Logistics response time includes the time from when a failed part is removed from the aircraft to when the serviceable part is returned to the supply system, including the time spent to transport the part to and from the repair facility and the time the part spends undergoing repair. To ensure that specific failed parts do not ground the entire airplane, extra spare parts are procured to replace parts being repaired. A shorter logistics response time means that failed parts are restored to serviceable inventory more quickly, so fewer total spares are required. The total cost of the inventory of these spares is lower when logistics response time is shorter.

Logistics response times affect the need for initial spares, used to fill the supply pipeline when the weapon system is first fielded, and replenishment spares, which are purchased on an ongoing basis. Although initial spares are typically purchased with procurement funds and are considered a nonrecurring cost, they provide for the logistics support of a weapon system, and so it is appropriate to assess the cost of initial spares as influenced by logistics support. Replenishment spares are bought on an ongoing basis as components on a weapon system are changed and as demand for spares fluctuates.

It should be possible to use modeling to assess the potential effect of logistics response time changes on the cost of spares in the future. Two things are required to conduct such an analysis. First, the program must reach maturity so that there is a history of part reliability rates, allowing a comparison of the F-22 to legacy programs that are supported organically. Second, the F-22 SPO must obtain information on comparable measures of logistics response time from Lockheed Martin and organic organizations.

The requirement for spares is a function of several characteristics of a weapon system, its usage, and its supply system. Weapon system characteristics that affect the cost of spares include the reliability of the parts[3] and the condemnation rate of the parts.[4] Usage characteristics include the number of flying hours and the aircraft availability goals. Characteristics of the supply system include logistics response time in its constituent durations, such as transporta-

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[2] Logistics response time is the elapsed time (in days) from customer requisition to receipt of materiel ordered from the DoD wholesale system. (Office of the Secretary of Defense, 2000.) Customer wait time, a similar concept that is used more frequently, is

> the total elapsed time between issuance of a customer order and satisfaction of that order. Ideally, [customer wait time] will include all customer orders, regardless of commodity or source, immediate issues, and backorders (and) include issues from wholesale and retail stocks as well as various other arrangements. (Office of the Deputy Under Secretary of Defense for Logistics and Materiel Readiness, 2009)

[3] Generally characterized as the mean time between failures or the mean time between repairs.

[4] The condemnation rate is a measure of how often reparables are not economical to repair and must be replaced with new parts.

tion, order and ship, and repair times, and—in a two-level maintenance system— the percentage of repairs done at each level.[5]

These characteristics, which determine the total cost of spares, are inputs in the Aircraft Sustainability Model (ASM) used to estimate requirements for initial provisioning and wartime spares for the F-22 program.[6]

Other models could be used to determine the relationship between logistics response time and the requirement for spares, or the relationship between repair-cycle time and aircraft availability. For example, such analysis was performed by Ramey (1999) on the C-5 program using the Dynamic Multi-Echelon Technique for Recoverable Item Control (Dyna-METRIC) model. Ramey found that a high-velocity logistics infrastructure that emphasizes speed instead of a large mass of spare parts could dramatically reduce spare-part inventory, storage, and overhead costs and could cushion the effects of fluctuations in demand (Ramey, 1999, p. xiii).

In order to quantitatively assess this potential benefit, it would be necessary to compare the contractors' repair-cycle times with organic performance on legacy aircraft, with faster repair times meaning that a lower number of spares in inventory is needed to maintain the same aircraft availability rate. However, a complete assessment is not possible at this time, for two reasons. First, the F-22 program is immature. Aircraft are still being produced, operating bases are still being stood up, and the fleet has accumulated relatively few flying hours. Repair-cycle times should be expected to be longer than at maturity because repair organizations and processes have not yet respectively learned or improved with experience. Therefore, it is not appropriate to compare the F-22 contractors' repair turnaround times against those achieved by organic organizations that manage mature legacy aircraft sustainment programs. It is also not fair to consider current F-22 logistics performance to be representative of what will be achieved once the program reaches maturity.[7]

A second reason that it is not possible to conduct a fair comparison between contractor and organic repair turnaround time is that the metric is measured in different ways by different organizations. The AFMC Manual 23-1 identifies repair-cycle time as depot repair-cycle days, defining it as "the time from the removal of an unserviceable item from the weapon system . . . on which it was installed, until the item is made serviceable through repair by an organic or contractor overhaul facility and returned to depot stock" (AFMC, 2007a, para. 23.8). The intervals that sum to depot repair-cycle time are also listed and defined in the AFMC manual. The intervals captured in the relevant government database do not include the time spent awaiting the parts needed to perform the repair. That is, the Air Force measure of turnaround or cycle time allows the clock to stop while materials needed for the repair are obtained. As such, it measures only a portion of the total repair process time, because it excludes the time required for supply chain response. Attempts to determine the average time spent awaiting parts for reparable items by querying the Air Force's Logistics Performance Assessment System (LogPAS) database proved to be unsuccessful because F-22 data for depot repair had not been entered into the source databases that feed the system.

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5 In two-level maintenance, components are removed and replaced in the field, then sent to the depot for repair.

6 The ASM was developed by Logistics Management Institute. It is used to forecast requirements for wartime spares for various Air Force programs, including the F-22. The model and its inputs are described in Slay et al., 1996.

7 With sufficient information about rates of improvement due to learning, as well as historical and projected demand rates for repair, an analyst could try to account for the differences in learning in the repair process at different levels of program maturity.

In contrast, contractors measure repair-cycle times without allowing the clock to stop—that is, their measure of cycle time includes time spent awaiting parts. Lockheed Martin provided repair-cycle times it has achieved to date. However, as explained in the preceding paragraphs, these times will not be representative of the mature F-22 program and are not comparable to organic programs because the Air Force measures turnaround time differently.

The immaturity of the F-22 would mean that currently available F-22 data may not accurately predict future repair times. However, modeling with more representative data and a model that accurately simulates actual experience could allow the Air Force to determine the value of potential differences in repair-cycle time attributable to PSIs.

Valuing Extra Mission Capability

DoD sustainment policy directs program managers to implement PBL strategies that achieve weapon system availability goals, subject to cost and logistics constraints, so the systems will be available for use when needed. Aircraft systems are deemed capable or incapable of performing their missions for reasons of either maintenance or supply. The PSI affects MC rates through its management of maintenance and supply functions. The PSI manages the supply chain and is responsible for the scheduling and work content of aircraft and engine depot maintenance; on the F-22 program, most organization- and depot-level maintenance will be performed by government personnel, regardless of the PSI, thus limiting the PSI's possible impact.

We assume that, even with the planned distribution of work, the PSI will be able to make a difference in MC rates. This section addresses how valuation might be attached to different MC levels, i.e., how capability differences might be monetized so that they are on the same dollar metric as operating costs. In addition, it provides a rough estimate of the value of any additional F-22 mission capability. Based on the range of availability rates observed for legacy fighters,[8] it is reasonable to consider how to value differences of 4–5 percent in the not-mission-capable-due-to-supply rates and even larger differences in overall MC rates. As will be discussed, estimating capability valuation is fraught with assumptions. However, because focusing solely on costs without considering capability issues may result in decisions that do not provide the best value to the Air Force, this section attempts to address benefits in the same monetary terms in which we addressed costs in previous chapters.

Traditionally, cost analysts think about how much a system costs, not how much it is worth. Because it is very difficult to determine the military value of a particular military system, this analysis will be greatly simplified by determining the value of capability as measured in cost per MC hour.

The Air Force tracks its operating and support costs in the Air Force Total Ownership Cost (AFTOC) system, which shows total F-22 operating and support expenditures by fiscal year. In return for that expenditure, the Air Force's Multi-Echelon Resource Logistics Information Network (MERLIN) shows flying hours, fully mission-capable (FMC) hours, and MC hours. (An aircraft is fully mission capable if it can perform all of its missions. An aircraft is mission capable if it can perform at least one of its assigned missions. By definition, MC hours and rates are always greater than or equal to FMC hours and rates.)

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[8] From FY 2000 to FY 2007, the not-mission-capable rates due to supply among mature fighter programs in the Air Force varied by 6.8 percentage points, and MC rates varied by 13 percentage points (data as of December 11, 2007, from Headquarters U.S. Air Force, Weapon System Sustainment Division, Multi-Echelon Resource and Logistics Information Network database).

Dividing the yearly F-22 operating and support costs by the number of flying hours, FMC hours, and MC hours yields a cost per flying hour, a cost per FMC hour, and a cost per MC hour. The calculated actual cost per MC hour could be used to infer the value of an extra hour of mission capability, for example.[9]

Ideally, the capability valuation estimates would be based on marginal cost, not average cost. While costs per hour described here are average costs per hour, it would be preferable to know the marginal cost of an additional hour. If there are many fixed costs in F-22 sustainment, the marginal cost of an additional hour could be far less than the average cost. If the Air Force has chosen the number of MC or FMC hours optimally, the marginal cost of an additional hour equals its marginal benefit. Unfortunately, the division of total operating and support costs by flying hours, FMC hours, or MC hours results in an average, not marginal, cost per hour. It is, however, an approximation for the purposes of this analysis and is readily available using AFTOC data.

There are at least two more caveats to the analysis. One is that funding realities constrain decisions to achieve aircraft availability. The Air Force may desire more or less availability at a given time, but it may have a limited ability to change funding levels to achieve the capability. A second caveat is that costs per hour for an immature program, such as the F-22, are likely to fall as the system matures, so the marginal cost per hour in the future will be less than it is now.

Despite these caveats regarding the cost per MC hour valuation estimate, this methodology offers a way to understand the value of differences in MC rates that the alternative PSIs may be able to produce. The estimate suggests that even slight changes in the fleet's MC rate may have considerable value. One can multiply the number of F-22 hours possessed by the fleet by an increase in the fleet MC rate and the marginal cost of each MC hour to determine the value of the increased mission capability. Although it is not possible to provide the details of our MC valuation analysis in this report, our top-level analysis illustrates that the value of minor increases in F-22 availability may outweigh cost differences across PSI approaches.

Methodology for Assessing Potential Benefits

This section explains the methodology used for assessing potential benefits associated with contractor and organic PSI approaches. In the course of this study, we visited and held discussions with representatives of Air Force and contractor sustainment organizations to learn about the sustainment services that they currently provide or would provide as PSI for the F-22 program. We spoke with individuals from Lockheed Martin and Pratt & Whitney who currently manage sustainment on the F-22 contracts. At the Air Force, we talked with representatives from organizations in all three ALCs that provide sustainment for Air Force fighter aircraft and engines, including the F-22 program. The Air Force representatives were generally from maintenance wings. Some were dedicated to the F-22 program, others worked on programs other than the F-22, and still others worked on various programs but participated on teams specific to F-22 issues, such as F-22 maintenance activation planning teams. We also received and reviewed briefings and other written materials. Consistent with the approach for assessing

9 It is important not to double-count using these metrics. For instance, an extra FMC hour might also imply an extra MC hour. But these metrics are not additive; our calculations divide total expenditures by total flying, FMC, or MC hours.

costs, we focused on benefits associated with PSI activities and ignored those associated with sustainment functions that would not change regardless of the PSI decision.

For each benefit asserted by a representative of a contractor or the Air Force, we determined whether the benefit was exclusive to one of the alternatives or applicable to both PSI alternatives. In most cases, the asserted benefits were not unique but differed as a matter of degree. We then tried to measure or assess the benefits using data and metrics described from Air Force logistics databases. These efforts were unsuccessful for reasons described later.

We assessed benefits from seven initiatives associated with the PSI function:

1. centralized asset management of spare parts
2. supplier base combined with other programs produced and/or sustained by the organization
3. information systems and databases
4. faster logistics response time
5. integration of supply chain management with engineering
6. funding flexibility
7. ability to create and use incentives to reduce costs under a PBL approach.

While we judge that some of these are in fact real benefits to the contractor (which can more quickly and flexibly invest in information technology, for example), we were not able to monetize them.

Another type of benefit relates to the organization managing the sustainment, rather than to the specific programs themselves. Thus, such benefits are not specifically related to the F-22 or F119 programs but may include the enhancement of organizational capabilities to manage other programs, for example.

Potential Benefits That Management Structure Could Affect

This section addresses seven difficult-to-quantify benefits and their potential contributions to the achievement of the performance objectives as detailed in the contract performance work statements.[10]

We note that, although the contractors have alerted us to the potential benefits of improved management techniques, these benefits are available to any PSI using such techniques. Not only are they difficult to quantify, with the exception of a couple of cases, it cannot be definitively demonstrated that the contractors will engage in more of these techniques or engage in them more effectively.

Centralized Asset Management of Spare Parts

The contractors assert that centralized asset management of spare parts on the F-22 allows the contractor inventory control point to manage all the spares in the entire program to achieve maximum aircraft availability. Spares can be moved from base to base or from production facility to base. To meet the demand for spares, all F-22 spare inventories are considered—not

[10] Much of the information on potential benefits was provided by Lockheed Martin in a limited-distribution white paper (Lockheed Martin, 2007, p. 4).

only those assets at base or wholesale supply. Because central asset management involves a larger inventory, buys for sustainment can be planned to coincide with buys for production or modification to achieve lower cost.

The contractors have claimed that, in the traditional organic approach, spares are not managed across the entire program, which can reduce the pool of available spares and increase the spare requirements for the total program. However, today, the Air Force does move parts among bases and commands to repair grounded aircraft when needed.

In addition, two current Air Force logistics initiatives, the Global Logistics Support Center and centralized asset management, are addressing this issue. Furthermore, the ability to move spares between production inventory and operational inventories is a relatively short-lived advantage that will end when production ceases.

Although potential benefits of centralized asset management include a reduced requirement for initial spares and reduced costs for spares through more efficient or timely purchasing, these potential benefits could not be quantified. And given the ongoing Air Force initiatives, it is not clear that contractors have or would continue to have an advantage in this area.

Combined Supplier Base

The contractors claim that they have the advantage of buying from a supplier base that supports all their programs—either production or sustainment—rather than buying for a single program. For example, Lockheed Martin's F-22 program shares many vendors with its F-35 program.

However, the counterargument is that the Air Force is improving its strategic management of its supply base, particularly by using commodity councils to source across programs for certain commodities, and through Expeditionary Logistics for the 21st Century initiatives, such as purchasing and supply chain management improvements that will use strategic sourcing and focused customer-supplier relationships to optimize the purchasing of spare parts.[11]

Although contractors have implemented strategic sourcing initiatives sooner than the Air Force and may have a current advantage in this area, it is not clear that contractors will maintain this advantage once Air Force initiatives are more fully implemented. The Air Force ultimately will be able to look across a broader set of programs when managing its supply base. Furthermore, it was not possible to assess the value of these benefits in either case.

Better Information Systems and Databases

A capable information technology system is required for effective supply chain management. Lockheed Martin and Pratt & Whitney claim to have deployed sophisticated supply chain optimization tools and to have integrated their systems with government systems and their own procurement and engineering systems. Air Force logistics personnel at Hill AFB agreed that contractors can change or update their systems more quickly than the government could.

The systems give the contractors the ability to integrate all of the programs and workload in the company and manage them efficiently. For example, the Oklahoma City ALC mechanics enter data into the Pratt & Whitney database as they work on engines, enabling Pratt & Whitney to know instantly which parts are used or consumed during the repair process. This, in turn, informs decisions when ordering new parts, reducing lead times.

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[11] Though the DLA is responsible for purchasing new spares, the Air Force retains all other supply chain responsibilities, including developing spare parts supply strategies.

A counterargument is that organic depot- and base-level supply systems have these same capabilities and that, without more details, it is not possible to compare the alternatives. We were unable to quantify the potential benefits in reduced labor, shorter procurement lead time for parts, or increased aircraft availability due to better information systems and databases.

Faster Logistics Time

F-22 contractors have proffered three reasons they can achieve shorter logistics response times than those provided by organic support. First, they claim that the government can eliminate the administrative lead time of the contracting process by establishing a performance-based guarantee with the contractor, rather than contracting for hardware as a deliverable. On the F-22 FASTeR contract, a negotiated representative spares list is prepared prior to award of the contract. Once the customer obligates funds on the contract, the contractor PSI determines what spares to buy. This arrangement avoids current government administrative lead time on spares contracts.

The Air Force also has the ability to use flexible contract arrangements, including contracts in which unit prices are specified but the quantity is not until the need arises. The Air Force can use PBL arrangements on procurement and repair contracts.

Second, the contractors assert that they make greater use of expedited shipping of parts between bases and depots. This shipping may be more expensive, but it is fast. However, organic sustainment organizations also use expedited shipping, so it is not clear that this represents a relative benefit to the contractor. The efficient use (not the total extent) of expedited shipping is the correct measure. Not all part deliveries are time-critical. For a weapon system with plenty of spare parts in the pipeline, expedited shipping may be wasteful. On the other hand, it may be cost-effective to avoid buying additional relatively expensive parts. There is also an advantage in shipping parts quickly to meet a temporary surge in demand for the part.

Third, the contractors claim that they make greater use of repair kits that accompany broken assets to the repair organization, so no time is lost waiting for parts. In a PBL environment, contractors are financially motivated to accurately forecast the demand for materials needed for repair and to shorten the time spent awaiting parts. Kitting helps meet these goals. However, organic depots have used kits for years, and we have no evidence to suggest that the contractors use them more frequently or efficiently. In addition, efforts to improve the efficiency of Air Force operations, including Air Force Smart Operations for the 21st Century (AFSO21),[12] should encourage an even greater organic use of these techniques in the future.

Integration of Supply Chain Management with Engineering

A potential benefit derives from the integration of two functional areas, supply and engineering, as well as the integration of various teams of engineers in development, production, and sustainment. The potential benefit is generated by the ability to use available funds in the most cost-effective way, as well as the ability to give teams the proper incentives to work together in order to reduce costs or improve performance.

Both the Air Force and contractors have integrated supply chain and engineering expertise. In the Air Force, engineering in support of supply chain management is at least partially funded by the BOCR rate that is charged to customers as part of the working capital–funded

[12] AFSO21 does not specifically mention kitting but encourages the use of "lean" and other initiatives to improve operations (see U.S. Air Force, 2006).

supply system. The organic and contractor PSI approaches differ in the degree of integration and the incentives they provide for the different functional teams to work together and achieve benefits. While it is easier for contractors to draw on development and production engineering expertise when the sustainment effort overlaps with the acquisition phase of the program, current plans call for the F-22 production to be completed in the middle of the period covered by this analysis, so this overlap will affect only a portion of the period covered in this research.

To support their assertion of benefits generated by the integration of the supply and engineering functional teams, Lockheed Martin provided a number of examples that include specific cost savings and/or improvements in reliability. However, it was not possible to estimate all the current or potential future cost savings or reliability improvements that would be attributable to the integration of supply chain management and engineering. Furthermore, it is not possible to rule out selection bias, because Lockheed Martin provided evidence only for the examples it chose to present. For these reasons, it was not possible to verify to what extent these are advantages relative to what an organic PSI could achieve.

Funding Flexibility

The contractors assert that they have an advantage in terms of funding flexibility. The government has different "colors of money," meaning that funds programmed for particular purposes cannot necessarily be used for other purposes. In contrast, contractors can use available operations and maintenance funding for engineering efforts to develop reliability improvements in hardware. Similar efforts by a government organization would typically require additional levels of detail, justification, and approval, all of which provide opportunities for delay. The ability to act quickly allows earlier realization of savings.

Again, it is not possible to estimate what effect, if any, greater funding flexibility would have on weapon system sustainment performance. Furthermore, the SPO has indicated that, in spite of the flexibility, it has received no indication that the contractors have made these investments in engineering reliability improvements using operations and maintenance funds independently.

Ability to Create and Use Incentives to Reduce Costs Under a PBL Approach

The purpose of a PSI under a PBL approach is to manage all sources of logistics support to meet negotiated performance outcomes. As described in previous chapters, regardless of whether the F-22 PSI is organic or contractor, organic organizations will be performing almost all the repair work, due to core and 50/50 requirements. The PSI will be responsible for the repair process and is the key entity in a PBL approach that motivates and is responsible for performance.

Although either a contractor or organic organization can function as a PSI, one or the other type of organization may have inherent advantages in creating and using incentives to achieve performance. Here, we explore the potential benefit of a contractor PSI to create and use incentives for performance.

A contractor PSI combines two inherent differences from the government that provide an advantage in creating and using incentives. Theoretically, the first difference is a more unified organizational structure, in which it is possible to identify a single manager responsible for all F-22 sustainment and who has authority over subordinates who conduct the F-22 sustainment activities. In contrast, it is difficult to identify a single Air Force leader responsible for the sustainment of a weapon system who also has authority over all of the individuals or organizations that provide sustainment for the system. However, in this case, the contractors are required to

hire government depots as subcontractors for repair and maintenance work and to use other government organizations, including the DLA, as part of the overall sustainment approach. Because of this constraint, the benefit to the contractors may be minimal relative to traditional CLS programs.

The second inherent difference between a contractor and government PSI is the use and structure of the PBL contract itself. Under a traditional sustainment approach, contractors are paid for each repair or other service. Thus, the greater the number of repairs or services, the greater the revenue. Under a PBL approach in which the contractor PSI is paid for performance, each repair is a source of cost. The PBL contract provides an incentive for the contractor PSI to improve system reliability and reduce repair costs. Incentives to reduce total costs exist if the PBL is issued under a firm fixed-price contracting arrangement (in which lower costs directly result in higher profits), not the cost-plus arrangements currently featured in the F-22 and F119 contracts (which are transaction-based). There are plans to transition to firm fixed-price contracts when the system is more mature and costs are more predictable, but their consideration is beyond the purview of this analysis.

In contrast, a government PSI would not operate under a contract with monetary rewards. If a systemwide organic PBL were used, the government PSI could be formally bound by a memorandum of agreement or memorandum of understanding that would stipulate desired levels of logistics performance. However, the government PSI would have a very limited ability to provide financial rewards for performance (typically in the form of small bonuses or comp time)—or sanctions for not performing—and would be coordinating and integrating support from disparate organizations outside its direct chain of command or authority. There are also limited possibilities for penalties if government organizations do not perform. The contractors would likely face related challenges, especially with regard to work that takes place at government facilities. Quantifying the effects of more powerful incentives would be difficult regardless of the approach.

The B-2 program provides insight into this issue. The B-2 is sustained largely by contractors under a PBL approach, and uses an organic PSI. Representative of the B-2 PSI provided insight into the challenge of providing incentives for performance.[13] For logistics support provided by contractors, the organic PSI provides incentives through contracts with award and incentive fees. In contrast, for logistics support provided by the government, the PSI or system support manager is trying to set aside a small amount of funds for new computers, furniture, and other items, as well as time-off hours as rewards for performance. However, approval for even this modest system of incentives requires action by general officers. Several government interviewees felt that this provided a smaller incentive than what the contractors can offer. They also noted that extra time off may be difficult to award in busy and perhaps understaffed programs.

Organization-Level Benefits

For the want of a better term, we characterize benefits to one or the other of the approaches that are not specifically related or linked to F-22 air vehicle or F119 engine performance as *organization-level* benefits. Our research effort focused specifically on benefits that were linked

[13] Notes from a teleconference with the B-2 PBL program manager and selected staff, August 10, 2007.

to the weapon systems, but we want to recognize the possibility that there are advantages that may confer to the PSI. These benefits can be considered as part of the decision regarding the sustainment approach.

The administration of air vehicle and engine sustainment efforts is a very complicated operation drawing on a wide range of managerial and technical skills. The F-22 and F119 PSIs will be responsible for integrating a wide range of inputs and outputs to meet the program metrics. Success is critical to maintaining weapon system mission capability. The PSI will benefit from this effort by the development of the knowledge and skills necessary for managing complex weapon systems sustainment. Several government interviewees raised concerns about maintaining the government's capability to manage these efforts. Using an organic PSI would help keep that capability vibrant.

Government Funding Flexibility

In other research, the authors of this report have found that CLS contracts for aircraft sustainment have sometimes been written in such a way as to limit the government's ability to decrease the amount spent on sustaining the aircraft in the contract (see Boito, Cook, and Graser, 2009). The idea underlying those contracts is that offering contractors a predictable amount of work enables a best-value (usually interpreted as the lowest price) contract. For example, the government might pay a fixed, agreed-upon amount to maintain an aircraft at a certain MC rate. However, when budgets are tight or priorities shift, these contracts limit the government's flexibility to move funds to more urgent needs. Notionally, the government may be contractually required to pay a contractor to maintain a fighter at a particular MC rate while not being able to afford to sustain enough tankers for effective operational use of those fighters.

Increased flexibility of funds is not necessarily a benefit that accrues to organic approaches because contracts can be structured in such a way as to include flexibility. However, if contracts are not written to include flexible requirements, then funding flexibility would favor the organic alternative.

Summary of Potential Benefits

DoD guidance on PBL suggests key metrics that can be used to measure performance outcomes. The metrics are operational availability, reliability, cost per unit of usage, logistics footprint, and logistics response time.

In the course of this study, the contractors provided us with a number of examples of the sustainment benefits that they provide. This chapter presented brief descriptions of a few of the main ones. We tried to independently assess and quantify the benefits using the five PBL metrics, but we were unable to do so due to lack of appropriate data.

Although we were unable to demonstrate that one sustainment approach or the other would provide better performance, two methodological excursions in this chapter (on valuing logistics response time and reliability through requirements for spare parts and on valuing extra mission capability) demonstrated the potential benefit, quantifiable in cost terms, of differences in logistics performance.

CHAPTER SEVEN

Other Findings

Introduction

The research conducted for this F-22 sustainment cost-benefit analysis identified a number of issues that were not directly applicable to the cost-benefit comparison but are important for any decisions that the F-22 SPO will make regarding the program's future sustainment approach. As stated previously, an immediate change in the current sustainment arrangement would be difficult to enact. This chapter addresses three kinds of issues and challenges that the F-22 SPO should consider during the next formal assessment of F-22 sustainment. These challenges include

- managing sustainment contractors effectively
- creating PBL incentives under an organic PSI
- developing a government analytical capability to conduct a comprehensive business-case analysis of sustainment alternatives.

Challenges to Managing Sustainment Contractors Effectively

This section addresses challenges that the F-22 SPO may face in its efforts to effectively manage the F-22 sustainment contractors during a difficult fiscal and contracting environment in the next few years—and potentially during a transition to an organic PSI. The challenges include how best to manage PBL in an environment marked by unstable funding, how best to manage the proposed transition from cost-plus to fixed-price contracts, motivating cost performance if the PSI were decoupled from other contractor-managed sustainment activities, and effectively transitioning PSI functions in the case of a transfer to an organic PSI.[1]

Achieving PBL Under Funding Shortages and Short-Duration Contracts

Adequate and stable funding over a multiyear contract is desirable and probably a necessary condition for implementing PBL effectively. Adequate funding is necessary for the PSI to achieve performance objectives and have sufficient resources to make investments that may

[1] An additional issue involving sustainment contractors, noted here but not discussed in the report, is the difficulty faced by any PSI, contractor or organic, in improving performance while ultimately dependent on monopoly vendors who can charge more than the fair market value for their goods or services. This monopoly power of a vendor may be offset by the monopsonist power of the PSI. In discussions with Air Force logistics personnel who are working with vendors on the F-22 program, we heard of such problems with only one vendor.

pay off over time. Stable funding is desirable to avoid frequent negotiations to match funding and performance and to ensure that the PSI has predictable resources and goals. Long contract durations are necessary to provide sufficient time for the PSI to recover the cost of investments made to improve sustainment performance.

The F-22 SPO faces challenges in providing these conditions. Funding may be available to allow marginal improvements in levels of aircraft availability, but little if anything beyond that.[2] Funding levels are unstable from year to year as the Air Force juggles competing priorities. Each change in funding levels necessitates another round of negotiation and analysis to determine what operational outcomes can be achieved with the available funding, with attendant delays and uncertainty for all parties. Finally, the current contract being negotiated for F-22 sustainment is a ten-year arrangement with priced options for the first two years and one-year options after that. Single-year or even two-year contract terms may not provide enough time for the PSI to invest in, and benefit from, improvements that would boost performance or reduce cost.

Given a fiscal and contracting environment over the next few years that is contrary to the conditions required to implement an effective PBL contract, the next F-22 sustainment business-case analysis will be assessing contractor performance under a cost-plus (rather than PBL approach). As a result, contractor performance by 2010 will not likely reflect what is possible under PBL. Continued funding instability and short-term contracts would likely preclude potential benefits of PBL, such as increased mission capability, from being realized. If this is the case, the PSI decision should focus more narrowly on costs rather than costs and benefits.

Transition from Cost-Type to Fixed-Price Contracts

Although the current F-22 air vehicle and engine sustainment contracts are cost-plus-fee contracts, the F-22 SPO intends to implement any future PBL contracts on a fixed-price basis[3] in order to guarantee a PBL outcome at a known and agreed-upon price. Assuming a transition to fixed-price sustainment contracts, the difference between the actual cost of sustainment and the negotiated price would be potential profit for the contractor.

During the current period of cost-plus contracts and the potential transition to fixed-price contracts, the SPO may have a twofold challenge. The first challenge may be determining a reasonable cost basis for the fixed-price contracts that are expected to follow. Because (as of this writing) the F-22 is still an immature program as procurement continues, it is difficult for the F-22 SPO to project future, steady-state sustainment costs.

The second challenge is one that affects any contract in which current costs serve as a basis for future negotiations and that motivates the contractors to optimize cost performance on the current cost-type contracts. If contractors push too hard to control costs now, their cost basis—and their future profits—could be reduced. In this analysis, we raise the possibility of a disincentive to reduce sustainment costs on the current sustainment contracts, although the contractors indicate that the fact that the F-22 has a constrained annual budget has placed strong cost pressures on the contractors. More generally, arrangements with shared savings from cost reductions offer one strategy to lower prices on future fixed-price contracts.

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[2] Decreases in funding and concomitant reductions in availability are more likely outcomes. Given the Air Force's many competing priorities, this flexibility may be useful on a corporate level even if it negatively affects the F-22.

[3] Fixed-price contracts may not need to be inflexible if there are predetermined levels of performance matching different possible levels of funding.

An in-depth business-case analysis, combined with the potential for transition to an organic F-22 PSI sometime thereafter introduces the possibility of competition and may provide the contractors with sufficient motivation to maximize their performance and reduce costs on the current cost-type contracts. This, in turn, would provide a reasonable cost baseline for future fixed-price tasks.

Transition of Functions Between PSIs and the Depots

A possible outcome of a business-case analysis completed circa 2010 could be the transition of F-22 sustainment management from a contractor PSI to an organic PSI. If PSI responsibilities shift from contractors to the Air Force, the SPO would need to carefully identify and manage the transition of select tasks and responsibilities, such as those detailed in Chapter Three.

In particular, the transition of business and contractual arrangements between organizations would require some unknown level of effort to accomplish. As the current PSI, Lockheed Martin is negotiating and arranging with OEMs for repair instructions so that Air Force depots can repair F-22 equipment. If an organic PSI is selected, the F-22 SPO would need to decide whether this responsibility would transfer to the organic PSI or remain with Lockheed Martin as part of its duties under public-private partnerships with the depots. It would require people with necessary expertise in logistics support of the weapon system, contracting, and cost or financial management, at a minimum, to determine which organizations are to perform various PSI activities, on what terms, and to negotiate an outcome. We cover the government workload increases (and contractor decreases) in Chapter Three but briefly repeat the discussion here to emphasize the tasks involved. Notable among this workload increase would be a one-time effort to contract with vendors for repair instructions and possibly other technical data for the repair of equipment, in addition to ongoing contracting with vendors for the purchase of spare parts.

The nature of the increased contracting workload could affect F-22 logistics support. Far more so than private-sector contracting, government contracting must follow many detailed regulations and requirements, such as the need to compete or obtain a waiver from the requirement for competition. It is possible that government contracting would add to administrative lead times for parts procurement, to name just one potential effect.

Creating PBL Incentives Under Organic PSI

This section addresses one challenge associated with an organic PSI: the difficulty of offering monetary incentives to organic PSI organizations and individuals.

A PSI under PBL is a formally bound entity responsible for logistics outcomes. Lockheed Martin and Pratt & Whitney can be formally bound by contracts, but an organic PSI would need a different mechanism, such as a memorandum of agreement or memorandum of understanding. Although the desired logistics outcomes may be the same regardless of the PSI decision, there are differences in the nature of the contracting or agreement methods that may present management issues for the F-22 SPO.

A contract with a private corporation to provide logistics support allows for the use of award and incentive fees to motivate performance. Through such contracts, individuals and organizations can be rewarded monetarily in accordance with their performance.

In contrast, memoranda of agreement or understanding in the Air Force do not allow the use of monetary incentives. In fact, under the working capital–funded system, when depot or supply organizations fail to meet their financial targets in a fiscal year, they must raise their rates the following year. Of course, there have been successful initiatives to make these organizations more efficient. But the difference remains that organic organizations do not have the same financial incentives as private-sector organizations to perform more efficiently or cost-effectively, nor do they have the same flexibility to offer incentives.

The same challenge holds true at the individual level. Although Air Force employees can earn bonuses for good performance, the size of the bonus is typically modest in comparison to the bonus opportunities available to private-sector contractors.[4] Instead, employees can be offered comp time as an incentive, but busy government managers and workers may not be able to take it and still get their work done.

Need for a Government Analytical Capability to Support Business-Case Analysis

This section provides a number of issues that the F-22 SPO should consider in preparation for a subsequent detailed analysis of the business case for a contractor or organic PSI. The full-scale business-case analysis, like our more limited cost-benefit study, should consider logistics performance and cost in addition to other factors. This section addresses the assessment of costs and benefits, including the schedule that should be allotted for the analysis.

Logistics Metrics and Databases

An analysis of the business case for alternative sustainment providers should include an analysis of logistics performance. Such an analysis will require data as well as the expertise and methodologies necessary to assess the data, as discussed next.

The Air Force has a multitude of logistics databases. Finding and using the appropriate source or sources of logistics information may present a challenge. The business-case analysis will probably assess measures of weapon system mission capability, awaiting-parts and MC status, customer wait time, logistics response time, and so on, and will probably need to filter the data by weapon system, repair or supply organization, type of item (e.g., reparables or Federal Supply Classification), or other criteria.

A key challenge in acquiring and analyzing logistics data in government databases is that information for CLS programs is not always recorded in the government data systems that feed them. Lockheed Martin's F-22 supply data are entered into the Standard Base Supply System (SBSS) but not the Wholesale and Retail Receiving and Shipping System (D035K),[5] so government logistics databases would not include information on F-22 depot repairs. Analysts wanting to assess F-22 logistics performance should be aware of this and may need to request and obtain the data from Lockheed Martin and Pratt & Whitney to assess activities not recorded in SBSS.

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4 Over 60 percent of federal workers receive bonuses, and the average bonus is 1.6 percent of annual salary, according to a study of FY 2002 federal records (Lee and Straus, 2004).

5 Email from Lockheed Martin, December 7, 2007.

Perhaps the most difficult challenge to overcome in comparing the performance of logistics support is that many metrics used to gauge logistics performance depend on the level of spare parts in the supply system, which, in turn, is affected by available funding, the reliability of parts in the weapon system, usage, and other factors. Because some of these factors—especially funding and usage—are outside the control of the logistics provider, it is important to measure those aspects of performance that the logistics provider can affect.

The discussion of benefits in Chapter Six included logistics metrics and, especially, logistics response time as measures of supply system performance. Because logistics response time can be affected by the level of funding for spares to fill the pipeline, it may be more appropriate to use an intermediate metric of logistics response time, such as pipeline segment flow times, to assess supply system performance.[6] Air Force Policy Directive 20-3 (1998) mentions the use of pipeline segment flow times and handling and transportation costs, among other metrics, to gauge the performance of reparable pipelines.

When assessing flow times, it is important to ensure that comparable measures are employed when comparing Air Force and contractor logistics support. As noted earlier, Lockheed Martin measures depot repair-cycle time without "stopping the clock" while awaiting parts. In contrast, the AFMC definition for depot repair-cycle days in allows the clock to stop while awaiting parts (AFMC, 2007b).[7] A comparison of contractor and organic depot repair-cycle times will require a database, or combination of databases, that will allow measurement of organic depot repair-cycle times, including time spent awaiting parts.

Finally, in assessing benefits, it would be desirable to link logistics performance to measures of weapon system cost or availability. This would require modeling capability to determine relationships among repair-cycle time, levels of funding for spares, and weapon system availability. It also would be desirable for the Air Force to be able to conduct such modeling independently of the PSI contractor.

Insight into Contractor Costs

Most Lockheed Martin costs are straightforward in the cost spreadsheets that supported the FASTeR proposal, as provided during the course of our cost-benefit study. Lockheed Martin's data enabled a straightforward identification of material costs, labor hours, and associated costs by function of the personnel. One area of ambiguity is costs that are part of the labor wrap rates, which include the costs of transporting and warehousing parts.

Organic supply system costs are visible in the working capital fund budget and include personnel, data and telecommunication services, transportation, and warehousing costs. In contrast, it was not possible to discretely identify these supply system costs for the contractors. Although their supply system personnel costs were identified as direct charges or as part of material wrap rates or material burdens, the contractors' data and telecommunication services, transportation, and warehousing costs were included in labor wrap rates and were not sepa-

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6 One could argue that a logistics system that is generously stocked with spares can afford to repair broken reparables more slowly, while a logistics system with a lower level of spares must repair broken reparables more quickly to achieve the same level of capability. In this way, and assuming that the two logistics systems are trying to achieve the same level of capability, the number of spares in the pipeline could affect flow times.

7 AFMC (2007b) provides guidance for items reported in the D200A and D200N databases. The manual defines depot repair-cycle days for these items as the sum of base processing days, reparable in-transit days, supply-to-maintenance days, shop flow days, and serviceable turn-in days.

rately identifiable. As a result, it was not possible to determine how the contractors' wrap rates would be affected if these functions were transferred to an organic PSI.

Recommendation on the Business-Case Analysis Study Schedule

Research conducted for this study revealed that making a change to the current sustainment strategy will take several years to complete. Therefore, if the Air Force does actually want to have the option of making a change within the next five to seven years, it is not too soon to begin planning for a follow-on, in-depth business-case analysis. As this research was under way, the C-17 SPO had begun to initiate a C-17 business-case analysis that was expected to take 18 months, plus an additional six months to vet it with stakeholders. At that point, the SPO was to decide which option to pursue—either organic or contractor PSI—and then, if necessary, release a request for proposals, evaluate the proposals for the follow-on contract, and make an award to be implemented by FY 2012.

CHAPTER EIGHT

Conclusions and Recommendations

At the request of the Air Force, PAF conducted a congressionally mandated study to compare the current plan for contractor-managed sustainment for the F-22 air vehicle and F119 engine with notional organic solutions in which the government would be in charge of sustainment management for the period from 2008 to 2012. Our analysis determined that the alternatives were close in terms of costs, but the benefits were impossible to quantitatively assess.

At this point in the F-22 program, changing course for sustainment is possible, but it would take several years. Over the next two years, the Air Force would need to program the required resources into its budget. It would need an estimated additional two years to hire the necessary employees and develop their human capital to enable them to manage F-22 and F119 sustainment.

Summary of Methodology

Since the Air Force would spend the first two years engaged in budgeting for the possible transition to an organic PSI, our analysis of the notional organic PSI assumed that costs are identical to those in the contractor PSI case for the first two years of the transition period, regardless of the selected approach. Organic personnel costs increase in the middle years of the transition period as the organic sustainment organizations stand up in parallel to the contractor PSI, and contractor personnel costs start to decline. In the final year of the transition, the organic organizations will be fully staffed, and their full costs will be counted because the organic PSI will assume supply chain management responsibility and costs in that final year. Because that final transition year would be the first year under an organic PSI, the cost comparison focuses on an analysis of the difference between contractor and organic costs in that year.

Our cost analysis found that a single-year comparison based on the workload in the final transition year is a reasonable baseline for a comparison going forward. By that year, the program will be more mature, and production will be complete. However, the cost differences rely on estimating assumptions (see Chapter Five for further considerations). Furthermore, a change in any of the underlying assumptions could change the outcome.

We also assessed benefits claimed by representatives of the contractors and government sustainment organizations. We found no definitive evidence to support claims that one or the other alternative offered clear advantages. Although it was not possible to validate and quantify the asserted benefits, it is reasonable to conclude that the potential performance benefits could outweigh the cost differences identified in the cost analysis.

Recommendations

An important implication of this analysis is that a full-scale business-case analysis to more accurately assess the costs of the two approaches should be conducted relatively soon. The program will be more mature and more insight into future costs will be available by 2010. Unless such an analysis is conducted, the Air Force will have limited ability to demonstrate whether contractor management of F-22 air vehicle and F119 engine sustainment represents the best value for the Air Force and the taxpayer. If a business-case analysis suggests that a transition to an organic PSI is called for, the Air Force will need to identify and manage the transition of many tasks and responsibilities from contractors to an organic PSI.

Attempts to motivate performance using a systemwide PBL contract would be challenging under an organic approach (although the complete benefits of PBL may be less available in a contractor PBL arrangement where much of the work will be conducted at government depots with limited contractor ability to control performance). No approaches have been identified to provide incentives to government workers or organizations as effectively as monetary awards can be used to motivate contractors. Government organizations cannot be paid an increased fee to perform more effectively. Individuals can get bonuses or comp time, but these are small incentives compared to those available in the private sector. Efforts should be made to find ways to create new incentives for improved government performance.

Along with providing incentives for better performance, the government could benefit by pursuing efforts to measure performance attributable to the logistics provider. An in-depth business-case analysis of the alternative F-22 sustainment providers should include an analysis of logistics performance and ideally allow the comparative assessment of the performance of alternative logistics providers. The ability to assess logistics performance requires reliable data as well as the expertise and methodologies necessary to assess the data.

APPENDIX A

The Costs of Technical Data

This appendix assesses the cost of technical data needed to perform depot repairs. In particular, we examine whether the cost of obtaining the technical data would differ under an organic or contractor PSI. We evaluated this concern and failed to find evidence that the cost of technical data is an important differentiator between the prospective PSI approaches.

Definition of Levels of Data Rights and Technical Data

Before going further, it is useful to clarify some terms related to technical data rights. The Federal Acquisition Regulation (FAR) governs civilian agency contracts and describes the regulations regarding the government's technical data rights in civilian agency contracts. The DoD FAR Supplement (DFARS) governs DoD contracts, such as those for the F-22.

The DFARS defines *technical data* as recorded information of a scientific or technical nature, including computer software documentation. The definition does not include computer software or data incidental to contract administration, such as financial or management information (U.S. Department of Defense, 1995).

The DFARS specifies three levels of technical data rights. In increasing order of restrictiveness, the levels of rights are unlimited, government-purpose, and limited:

> "Unlimited rights" means rights to use, modify, reproduce, perform, display, release, or disclose technical data in whole or in part, in any manner, and for any purpose whatsoever, and to have or authorize others to do so. (U.S. Department of Defense, 1995)

Government-purpose rights are slightly more restrictive and provide the right to "[u]se, modify, reproduce, release, perform, display, or disclose technical data within the Government without restriction" and allow release outside the government for similar uses, subject to the requirement that the data are used for United States government purposes:

> Government purposes include competitive procurement, but do not include the rights to use, modify, reproduce, release, perform, display, or disclose technical data for commercial purposes or authorize others to do so. (U.S. Department of Defense, 1995)

The most restrictive category is limited rights, which allows the use of the technical data within the government but closely restricts the release of the data outside the government.

The level of technical data rights to which the government is entitled depends on the source of funding for the noncommercial item. The government is entitled to unlimited data

rights for items developed exclusively with government funds. It is also entitled to government-purpose technical data rights for items developed with a mix of government and nongovernment funds. It is entitled to limited technical data rights for items developed exclusively with private funds.

Technical data, as discussed in this appendix, refers to the instructions that organic depots need to maintain and repair F-22 equipment. Because the maintenance and repair work will be done in government facilities, the government is entitled to the technical data needed to perform the repairs under any of the three levels of data rights.

Technical data can refer to detailed drawings that would allow a second source to manufacture the item. This is what is commonly thought of as data rights, although it is only a subset of what data rights can encompass. Such data are not at issue here, because the focus of this study was limited to sustainment. We believe that it is likely for the PSI (government or contractor) to purchase replenishment parts from the original OEMs, and procurement from a second source is not expected. A separate cost-benefit analysis comparing the cost of the purchase of the data rights necessary for manufacturing with the potential benefits from competition would need to be conducted to assess an alternative approach.

Technical data can also refer to records of usage, repair, and repair rates; such data are being gathered by the Air Force as the F-22 accumulates flying hours. These data are unrelated to the PSI decision.

F-22 Technical Data

Under the traditional organic depot maintenance approach, the government bought technical data rights as part of the system acquisition process. However, the F-22's evolution was different. Initially, the government planned to purchase data rights. Some time after the decision was made to follow a CLS strategy, it was determined that the government would not buy technical data rights—or, at least, rights to the technical data in a specified format—because of budgetary constraints. When the CLS decision was later altered to include the use of organic sources to perform depot-level maintenance, the Air Force did not own the requisite repair instructions.

The *F-22 Life Cycle Management Plan* (F-22 SPO, 2007a) cites a 1995 logistics privatization study estimate that developing military specification–compliant technical order data would cost more than $100 million in budget year 1990 dollars (or more than $200 million in FY 2007 dollars). We have not found a more current estimate for technical order data, and we are unable to verify its validity. Contractors would incur costs if they were asked to develop a new estimate, so we could not ask for this as part of our study.

We do note that the original estimate may be based on outdated premises. Military specification–compliant instructions are no longer necessary; commercial standard instructions now suffice. In fact, it has been the SPO's intention to require the contractors to provide commercial-like depot repair instructions. The reasoning for this approach was to streamline the management of data and attendant costs by not developing depot-level technical orders. This approach will facilitate the ability to revise and distribute repair instructions to the ALCs in a cost-effective and expedient fashion.

Recent Sources of Technical Data Costs for the F-22

Regardless of the total cost of developing repair instructions, the germane cost estimate for our purposes is the estimated cost difference associated with organic versus contractor PSI. Organic depot maintainers will need repair instructions irrespective of the identity of the PSI. We are not directly concerned with how much the instructions cost; we care about how much that cost estimate might change if there were an organic F-22 PSI.

Depot partnering assessments (DPAs) often include estimates of technical data costs. We received eight DPAs for F-22 workloads. Five of the eight DPAs contain estimates of technical data costs, which vary widely.

The other three DPAs we received combine technical data with other types of nonrecurring costs, so the specific costs of work instructions are not identified. The eight DPAs we received are only a fraction of the depot maintenance partnerships that are envisioned. We have received indications that their data rights cost estimates may not be representative of what is to come. The workloads for those eight DPAs do not involve any software-related depot maintenance partnerships. We interviewed people involved in standing up F-22 depot capability, some of whom cautioned us that the workloads that have been stood up so far—like those in the eight DPAs—are not representative of the remaining F-22 workload. They cautioned that the remaining workload, which involves more avionics and software, may present additional challenges and higher costs.

Our interviewees offered at least three factors that may influence the cost and difficulty of obtaining technical data. One factor is the amount of privately funded content, which gives rise to contractor claims of restricted rights. The amount of privately funded content is expected to be larger for avionics and software, areas in which more content may be used from commercial products.

A second factor that could influence the cost and difficulty of obtaining technical data is whether the government negotiated clauses for repair instructions during the development phase of the program. When the Air Force's planned sustainment approach for the F-22 was CLS for the life of the system, the Air Force decided as a cost-saving measure not to buy contract options for repair instructions, at least on some F-22 contracts. Now that the program is in the sustainment phase and is in a less favorable negotiating position, the price of the repair instructions is likely to be higher than if the Air Force had negotiated prepriced options for the technical data during development.

A third factor that could influence the cost and difficulty of obtaining technical data is the business strategy of each contractor and its willingness to give up a future revenue stream from repair work. Discussions with many weapon system contractor and Air Force personnel indicated that it has been difficult for many contractors to give up the expectation of a stream of revenue from selling parts or repairs under a traditional arrangement for sustainment. They may view the provision of data rights as representative of lost business and so may be less inclined to negotiate.

Our interviewees indicated that, once companies learned of the limitations on sustainment location caused by core and 50/50 regulations, which require almost all F-22 depot work to be performed in organic depots, they were generally willing to give up their expectations for future repair work. A willingness to provide repair instructions at reasonable prices seems to be part of the change in expectations.

The depot partnering arrangements that have been set up to date involve a contractor PSI. Lockheed Martin as PSI has taken the lead in negotiating with vendors to obtain the repair instructions needed at the depots. Lockheed Martin has contractual arrangements with its subcontractors, which have no direct contractual relationship with the Air Force for this specific work. If the Air Force moved to an organic PSI, the existing contractual arrangements would need to be altered. One option would be for the new organic PSI to simply pay Lockheed Martin and/or Pratt & Whitney to continue their roles managing depot partnering arrangements with OEMs.

Another option would be for the organic PSI to set up its own agreements with existing depot partner OEMs. The Air Force might be able to take over existing contracts. We are not qualified to evaluate the legal issues that may arise in this context, however.

Depot activations of F-22 workloads (except software) should be complete by 2012 (F-22 SPO, F-22 Depot Activation Team, 2007). If there were yet-to-be-completed partnerships under an organic PSI, the organic PSI could set up new arrangements or pay Lockheed Martin or Pratt & Whitney to do so.

An organic PSI does not, axiomatically, imply traditional organic depot maintenance. If the organic PSI chooses, it could continue to use the depot maintenance public-private partnership mechanism. While it is unlikely that an organic PSI would hire a contractor to manage work done at depots, this could be done. It would be one way of avoiding the cost of developing new contracts with OEMs, although it would involve other costs, including a variety of surcharges.

Cost Implications of PSI Choice for Technical Data

There are many uncertainties regarding the cost implications for technical data if the F-22 changed to an organic PSI. How large of a payment would Lockheed Martin or Pratt & Whitney require to continue to manage existing depot maintenance partnerships? Alternatively, how much would it cost to set up new arrangements with existing depot partners?

Looking toward future partnerships, would it be cheaper to hire Lockheed Martin and/or Pratt & Whitney and set them up than it would be for an organic PSI to make its own arrangements? Who has better leverage and negotiation skill with OEMs, and how much will data rights costs differ as a consequence? Would there be any remaining partnerships to set up by the time a prospective organic PSI takes over?

Summary

We think concern over technical data costs may have been overstated. The cost estimate for technical data rights that was developed in 1995 appears to be based on premises that are no longer valid. In particular, the F-22 SPO is endeavoring to develop and use commercial-like repair instructions to minimize technical data costs. In addition, most contractors thus far appear to be cooperating in PBL arrangements, including providing repair instructions for organic depots at reasonable prices. However, avionics and software workloads have not yet been stood up in organic depots, and many F-22 program participants expect them to be more problematic.

Some data rights costs will be incurred irrespective of who performs the PSI role. Depot employees need to have repair instructions. However, those instructions may not need to be military specification–compliant. When a contractor PSI negotiates with OEMs, the government's manpower needs are reduced, but Lockheed Martin or Pratt & Whitney is paid for this service. We have not found any evidence that, on net, having Lockheed Martin or Pratt & Whitney handle these negotiations reduces or increases government costs for these repair instructions.

If a decision is made to transition to an organic PSI approach, the Air Force would have to develop new arrangements with OEMs to access repair data. Fortunately, many have been reported to be easy to work with. Further, if a transition to an organic PSI occurs far enough in the future, many of the initial partnership negotiations between the prime contractors and OEMs will have been completed. It is likely to be more straightforward to rearrange existing partnerships than to create them anew.

APPENDIX B

The F-22 Process for Assigning Depot-Level Reparable Workload

In addition to undertaking the cost-benefit analysis, the F-22 program office asked the PAF study team to assess the F-22 process for assigning DLR workload. *DLR workload* refers to F-22 airframe and F119 engine component repairs that are too complex to perform efficiently at F-22 operational installations. Instead, they must be undertaken by depots. These depots could be government- or contractor-operated repair facilities. However, Title 10 requirements compel that most F-22 repairs take place at government-owned facilities to meet core and 50/50 requirements.

The DLR workload assignment process has three stages:

- The Source of Repair Assignment Process (SORAP) determines "the best long-term depot maintenance source of repair . . . while giving full consideration to the requirements of public law, Air Force policy, and which maximize weapon system sustainment to the warfighter with minimum use of scarce [Air Force] resources" (AFMC, 2007b, p. 2).[1]
- The depot maintenance interservicing (DMI) process "determines the final Source of Repair location with consideration to all DoD services" (AFMC, 2007b, p. 2).
- The Depot Partnering Assessment (DPA) "details the minimum requirements needed to stand up partnered depot-level repair capabilities" (F-22 SPO, 2006b).

We concluded that the Air Force DLR workload assignment process misallocates effort, with considerable work going into documenting already-decided outcomes and insufficient attention to where uncertainty exists. All F-22 SORAP reports that we examined have the same conclusion: Organic provision is chosen. Considerable effort is expended developing SORAP reports, but the outcome for the F-22 is rote.

Conversely, the DMI process does not always have enough information to fairly compare Air Force to other DoD (e.g., Navy) depots that could potentially serve as SOR locations. Finally, DPAs essentially produce estimates of the nonrecurring costs of setting up depot partnerships. They contain analyses of partnerships' recurring costs, too, but these recurring cost estimates do not appear to be important or decisive in decisionmaking. It would be helpful if the DMI process were to include the same type of cost information presented in DPAs. The following sections present more detail on each stage of the DLR assignment process.

1 More information on SORAP can be found in AFI 63-107, 2004.

The Source of Repair Assignment Process

As noted earlier, the SORAP determines "the best long-term depot maintenance source of repair . . . while giving full consideration to the requirements of public law, Air Force policy, and which maximize weapon system sustainment to the warfighter with minimum use of scarce Air Force resources" (AFMC, 2007b, p. 2). In fact, as they pertain to the F-22, the requirements of public law and Air Force policy lead to a predictable decision in favor of organic provision, which renders resource requirements a secondary consideration in the decision.

We reviewed a number of F-22 SORAP packages, as listed in Table B.1. They were provided by the F-22 SPO and represented all of the packages completed as of the date of this research. As shown in Table B.2, each package followed a very specific template. Every SORAP report included the same categories and had exactly the same answer provided in many of those categories.

Every SORAP package we examined used the same core requirement rationale for the organic depot choice presented in the bottom right of Table B.2.[2] Since every SORAP package included the same recommendation and stated rationale for organic provision, it underscored the repetitive and unvarying nature of these packages.

Table B.1
F-22 SORAP Packages

SORAP	Program Director Signature Date
Landing gear systems	2-25-05
Electrical power system	5-24-05
Hydraulics power generation system	5-24-05
On-board oxygen-generation system	5-26-05
Missile launch detection	9-15-05
Fuel system	11-18-05
Gun system	1-20-06
Weapon suspension and launcher system	1-21-06
Environmental control system	4-25-06
Flight control surfaces	6-24-06
Wheel and brake assemblies	2-2-05
Cockpit control system	2-15-07
Display system	2-15-07
Engine anti-ice system	2-15-07
Operational flight programs	3-20-07

[2] 10 U.S.C. 2464 discusses "core logistics capabilities." Core logistics capabilities are capabilities that are necessary to maintain and repair a weapon systems no later than four years after the systems achieve initial operational capability. The Secretary of Defense must ensure the performance of core logistics workloads necessary to maintain core logistics capabilities at government-owned and -operated facilities.

Table B.2
Source of Repair Assignment Process Template

Category	Typical Answer
System/subsystem name	
Military designator	
System description and inventory	
System priority rating	
Final application	F-22 aircraft
Technology assessment	
Cryptologic description	Not applicable
Wartime capability	
Candidate depot	Ogden/Oklahoma City/Warner Robins
Core assessment	This workload is a core candidate
Status of the mission assignment	
Workload description	
Depot peacetime workload hours and cost estimates	
What is the recommended depot-level repair source?	Ogden/Oklahoma City/Warner Robins
What is the rationale for the recommendation?	Workload associated with this SORAP is determined a necessary candidate to fulfill a core requirement.

In the case of the F-22, the SORAP is dominated by core considerations. Almost all F-22 depot-level maintenance work has been designated "core." Every major F-22 subsystem's workload is a candidate to satisfy a core capability requirement (AFMC, 2002). Further, the Air Force is striving to fulfill 50/50 requirements.[3] Hence, by Air Force policy, F-22 depot-level maintenance will be performed by organic personnel as much as possible.

It is important to emphasize a nomenclature subtlety: The "A" in "SORAP" stands for *Assignment*, not *Assessment* or *Analysis*. In the case of the F-22, all SORAP packages that were examined have the same bottom line: The DLR workload is to be assigned to an organic source. However, these decisions were made on the F-22 program for reasons other than "minimum use of scarce Air Force resources," i.e., the lowest-cost alternative. Legal requirements to meet core capability take precedence.

Assignment to an organic source does not necessarily imply assignment to an Air Force depot. F-22 depot maintenance work performed at Naval Air Depot (NADEP) Jacksonville or other Navy maintenance facilities would qualify as helping to fulfill the Air Force's 50/50 and core requirement. But because the SORAPs often occur early in the program, the SORAP packages do not have the detailed cost and workload information one would need to fairly

[3] 10 U.S.C. 2466 requires that not more than 50 percent of the funds available in a fiscal year for depot maintenance may be used to contract the performance of depot maintenance workload by nonfederal personnel (GAO, 2000; see also AFMC, 2006).

compare, for instance, Oklahoma City ALC to NADEP Jacksonville (and it is similarly difficult to compare contractor and organic SORs). It is also likely that alternative depots would vary in their ability to complete maintenance tasks.

The Depot Maintenance Interservicing Process

The lack of detailed cost, workload, and performance quality information is a shortcoming in fulfilling the requirements for interservice depot decisions. As noted in the *Depot Source of Repair Implementation Guide*, "no obligation of funds to establish a depot maintenance capability shall be accomplished prior to the DSOR [depot SOR]/DMI decision" (AFMC, 2007b, p. 5). Undertaking a fair and complete DMI analysis would require gathering many data not provided by the SORAP.

With respect to the F119 engine, the Joint Group on Depot Maintenance indicated that "technical data needed to conduct a comparative analysis between Oklahoma City ALC and NADEP Jacksonville was not available" (Joint Group on Depot Maintenance, 2005). The group concluded that

> continuing with the joint DSOR assignment process was neither feasible nor practical. While the Navy did not concur on an Oklahoma City ALC source of repair, the circumstances led to the Joint Group on Depot Maintenance agreement that Oklahoma City ALC is the de facto source of repair. It was acknowledged that this result did not meet the full intent of the joint DSOR process.

In this instance, the DMI process was not able to undertake the interservice comparative analyses that would have been appropriate. F-22 SPO personnel explained that subsequent DMI analyses have been compliant with the joint DSOR process, although no F-22 depot-level maintenance work has yet gone to a Navy depot.

Depot Partnering Assessments

While the preceding steps are intended to choose whether and where to assign organic DLR repair, DPAs present data on the nonrecurring and recurring costs of CLS, partnered depot maintenance, and traditional organic depot maintenance. A key output of DPAs is an estimate of the nonrecurring costs to set up a depot-level partnership. This estimate is emphasized (often in boldface) in each DPA's executive summary.

DPAs provide considerably more information than SORAP packages. (The SORAP process occurs earlier, and fewer data are available as inputs.) DPAs start with an executive summary noting who is involved and the estimated nonrecurring costs of partnerships, culminating in a recommendation as to whether and when to stand up a partnership.

After the executive summary is an objective statement,[4] ground rules (e.g., all costs in baseline 2005 dollars), assumptions (e.g., contractor repair specifications and instructions will

[4] F-22 SPO (2005c) includes the objectives "Provide best value to the USAF" (p. 6), "Cause no degradation of war-fighter support" (p. 6), and "Assessment recommendation and data collected will support additional analyses such as SORAP and 50/50" (p. 7).

be utilized), and a description of how the item is currently maintained (see F-22 SPO, 2005c, pp. 6–7). Then, the proposed partnering approach is described. Responsibilities are delineated between the OEMs, the contractor PSI, and the applicable depot. For example, the depot is to perform the maintenance per the OEM's work instructions. A repair flow process diagram is provided. A functional support plan (e.g., training, facilities, equipment, parts, technical data) is set forth.

All DPAs include a business relationship diagram. This diagram shows the contractor PSI (Lockheed Martin/Boeing, Pratt & Whitney) in the center, with the SPO contracting with the contractor PSI and, in turn, the PSI contracting with the OEM. The relationship between the PSI and the government depot is governed by a direct sales agreement or a direct sales implementation agreement. There is only a "broken-line" relationship between the OEM and the government depot, indicating a connection because of the location of the workload but the lack of a direct contractual relationship.

The DPA also includes a workload analysis with much more detail than that presented in a SORAP package. Units to be repaired or overhauled and associated workload hours by year are projected. This is followed by an analysis of nonrecurring and recurring costs of a partnership, CLS, and traditional organic depot-level maintenance. After the cost analysis, a variety of qualitative factors, such as Title 10 core compliance promotion of partnering, continued involvement of the OEM, and aircraft availability, are examined. Next is an overall risk assessment, i.e., possible problems and plans for their mitigation. Finally, the alternatives are summarized and a recommendation is made. It could be the case that, for DPAs (as with the SORAP packages), cost is a consideration in decisionmaking, but compliance with Title 10 requirements and DoD direction on partnerships is paramount.

There is a tacit decisionmaking criterion that partnerships should be implemented unless their nonrecurring costs (less CLS nonrecurring costs) are too large relative to the number of depot-level labor hours involved. No DPA, however, articulates a cutoff for how large partnerships' nonrecurring costs could be on a per-labor-hour basis.

DPAs also have been the subject of a number of criticisms. For example, DPAs assume that labor hours would be the same across CLS, partnerships, and organic maintenance. This assumption precludes the possibility that either contractors or depots might be more productive. On the other hand, the DPAs accord no advantage to competition. In a CLS situation, the contractor would be a monopolist that would presumably have limited incentive to provide the Air Force with a competitive price on repairs.

Air Force personnel also were concerned that the CLS cost estimates in the DPAs were understated. One concern was that overly optimistic assumptions were made about transferring equipment from contractor production to repair lines. There is no way to independently assess the validity and magnitude of this concern.

These criticisms assume, however, that the DPAs' cost estimates matter at all. Based on our analysis of the eight DPAs, we questioned whether the DPAs' recurring and total cost estimates were important. Given the paramount importance of complying with the core and 50/50 laws, it appears that cost considerations are secondary and perhaps largely irrelevant.

We believe that the key output of the DPAs is the estimate of how much up-front funding is needed to implement the desired organic-contractor partnership because such nonrecurring cost information is needed for budgeting purposes.[5]

Summary

The F-22 DLR workload assignment process appears to be useful mainly to meet an administrative requirement rather than to provide information that is useful for decisionmaking purposes. SORAP reports are arduously constructed, but all have the same conclusion. The DMI process needs more and better data to fairly compare different government depot options. DPAs gather considerably more cost data that might have been useful during the DMI process. Yet, many of these data (e.g., recurring cost estimates) do not appear to influence DPA decisions.

The SORAP has been dominated by high-level F-22 core and 50/50 decisions. It is unclear what value F-22 SORAP packages are adding, given the homogeneity of their decisions.

The DMI process is handicapped by a lack of cost information. It would take considerable data to reasonably compare, for instance, Air Force and Navy depot provision. The DPAs' cost data would be helpful for interservice comparisons, but they follow the DMI decision.

The DPAs' key output is an estimate of depot partnership startup costs. These startup cost estimates may prove useful for budgeting purposes.

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[5] Nonrecurring costs of core depot activations are funded by procurement (3010) funding, budget program 19.

APPENDIX C

F-22 Sustainment Activities

This appendix lists some of the major functions required to sustain the F-22. Table C.1 shows the functions, tasks, and responsibilities that would remain the same under either an organic or contractor PSI. An "X" signifies whether the work is performed by the government (organic) or by the contractor. Table C.2 shows those functions, tasks, and responsibilities that could be shifted from the current contractor PSI sustainment approach to an organic (DoD) sustainment approach. The arrows in that table indicate that the work could move from the contractor to the government under an organic approach. The number of functions, tasks, and responsibilities listed here is an indication of the complexity of sustaining a modern fighter aircraft.

Table C.1
F-22 Sustainment Activities That Would Be Constant Under Either Contractor or Organic PSI

Function or Activity	Organic	Contractor
Base-level functions		
On-aircraft maintenance	X	
Standard base level; supply system operation (including interface with core automated maintenance system, D035T for shipping items, D043A for master item identification, the Federal Logistics Database, D002A the standard base supply system, and D087 for weapon system management information system)	X	
Intermediate F119 maintenance	X (limited)	X
Base-level support to IMIS		X
Training device management, maintenance, and repair		Per AFI 63-111, training devices must be contractor supported
Administration, maintenance, and repair of the Mission Support System and Operational Debrief System		X
"O"-level engine maintenance at Lockheed Martin's Palmdale facility		X
Common support equipment management and repair (base level)	X	
Field service representatives (engine and air vehicle)		X
Provisioning of readiness spares packages	X (nonrecurring activity)	X
Communication security support for mission support cryptographic unit (National Security Agency standards for KOV cryptographic security card)	X	

Table C.1—Continued

Function or Activity	Organic	Contractor
Depot-level/SPO/system support manager functions		
Support system management duties	X	
Air vehicle depot repair	X	X
Engine repair	X	X
DLR repair	X	X
Support equipment repair	X	X
Core workload (depot maintenance labor)	Must be performed at a government depot, per public law	
Software maintenance	X	X
Contract and financial management functions for prime contracts	X	
Off-base functions: supply chain activities		
Common consumable supplies and DLR procurement, distribution, and inventory management	X (DLA responsibility)	
Procurement, wholesale inventory management for peculiar cartridge- and propellant-actuated devices, communication security, government-furnished equipment, explosives, and electronic warfare expendables	X	
Other Off-Base Functions		
Overall program management	X	
System-level operational and security requirements determination	X	
Contract management for prime contracts	X	
Modification development and integration (research and development)		X
Modification production		X
Modification installation	X (either ALC or contractor)	X (contractor for trainers)
Operational safety, suitability, and effectiveness responsibility	X	
Sustaining engineering (platform-level) and aircraft battle damage repair support	X	X
Unique identification management		X
IMIS management, hardware and software maintenance and repair		X
Contingency operations/catastrophic aircraft damage	X	X
Processing and disposition of reports of deficiency	X	
Support of Aircraft Structural Integrity Program	X	X
System effectiveness and threat analysis, maintenance of scenario databases		X

Table C.1—Continued

Function or Activity	Organic	Contractor
Low-observable maintenance auditing		X
Administration of Signature Assessment System, low-observable repair data set, support of range flights, managing signature of the fleet		X
Managing integration of aircraft configuration with training system configuration		X
Nonrecurring functions		
Site activation planning	X	X
Transition of repairs from vendors to partnering SORs	X	X

Table C.2
F-22 Sustainment Activities That Could Change from Contractor to Organic PSI

Function or Activity	Organic	Contractor
Base-level functions		
F-22 information resource management hardware and software	← Some work will likely move.	New requirement with F-22; some work will likely remain with contractor.
Maintenance and other communications, connectivity for site operations	←	New requirement with F-22
Tech data interface support of DoD and contractor systems (Joint Computer-aided Acquisition and Logistics System[a] interface to Enhanced Technical Information Management System)	←	New requirement with F-22
Conference hotel 24/7 support	←	Currently performed by the Technical Support Center
Support planning (planning, tracking, status reporting, cost analysis, and integration of changes for heavy maintenance and modifications)	←	
Establishing stock levels, procurement, reporting, and satisfying all base requisitions for unique F-22 consumable supplies and DLRs (includes subcontract management, distribution, inventory management)[b]	←	
Financial and inventory status reporting for items over $100,000	←	
Accountable official and custodial duties for peculiar support equipment	←	
Mobility kit maintenance for each deployable employee	←	
Other functions		
Overall supply chain management and planning	←	
Contract and financial management functions	← Subprime contracts	Currently, prime contract with suppliers and depots

Table C.2—Continued

Function or Activity	Organic	Contractor
Data collection and analysis	Collection and analysis (if database is purchased)	← X (partial; some analysis to go organic, some to stay with the contractor)
Peculiar component-level requirements computations	←	
Peculiar component-level systems engineering (line- and shop-replaceable units)	←	
Configuration management and control	←	
Wholesale supply chain management/inventory control point	←	
Operation of Technical Support Center	← (currently some Air Force staffing support)	
Support to F-22 sustainment planning structure	←	
Depot maintenance and repair scheduling	←	
Air vehicle/engine integration	←	
Quality assurance management	←	
Government-furnished property/government-furnished equipment management	← (some already with Air Force)	
Link service access point management (integration with ATLAS, Integrated Document Archiving and Retrieval System databases)	← (gathering data is with Air Force)	Analysis stays with contractor (Logistics Composite Model simulations)
Aircraft and engine analytical condition inspections management	← Labor is currently performed at ALCs	
Data analysis, including logistics support analysis data	←	Logistics support analysis consists of drawings, failure data, and repair data, all of which are now totally Lockheed Martin responsibilities. If moved, a new system of data would have to be developed if transitioned to Ogden ALC.
Maintenance of force structural maintenance plan, Force/Life Management Process, and Weapon System Integrity Life Management Plan	←	
Wholesale management of aircraft and F119 readiness spares packages	←	
Processing and disposition of quality deficiency reports, production quality deficiency reports, software deficiency reports	← (some aspects currently with Air Force)	
Coordinate and schedule F119 shipments	←	

Table C.2—Continued

Function or Activity	Organic	Contractor
Peculiar support equipment management and repair	←	
Diminished manufacturing sources analysis and information	←	
Technical order and time compliance technical order maintenance (Integrated Electronic Tech Manual block-cycle updates)	←	
Management, forecasting, and maintenance of support equipment and associated spare parts; identification, documentation, and approval of support equipment requirements, including procurement through delivery of assets	←	
Data engineers to the 53rd Air Warfare Center (Eglin) for reprogramming intelligence and other data to support operational deployment of the F-22	←	

[a] A replacement for three Air Force tech order systems.

[b] Low-observable maintenance materials are a significant factor on the F-22.

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